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Ecological Risk Assessment
Port of Redwood City Wharf 3 Area
Sims Metal Management

Prepared for

Sims Group USA Corporation

March 1, 2018

Prepared by: Windward environmental LLC

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Acronyms

BAF	biota accumulation factors
BAZ	biologically active zone
BTAG	Biological Technical Assistance Group
BW or bw	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	constituent of concern
CSM	conceptual site model
CSTAG	Contaminated Sediments Technical Advisory Group
dw	dry weight
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ERM	effects range – median
FIR	food ingestion rate
HQ	hazard quotient
LOAEL	lowest-observed-adverse-effect level
MLLW	mean lower low water
NOAEL	no-observed-adverse-effect level
NWR	National Wildlife Refuge
PCB	polychlorinated biphenyl
Port	Port of Redwood City
PRG	preliminary remediation goal
SCCWRP	Southern California Coastal Water Research Project
Sims	Sims Group USA Corporation
SIR	sediment ingestion rate
SUR	site use factor
SWAC	surface-weighted average concentration
TRV	toxicity reference value
UCL	upper confidence limit
UTL	upper threshold level
Windward	Windward Environmental LLC

Submittal Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: Lisa Saban

Name: Lisa Saban

Title: Partner

Date: March 1, 2018

1 Introduction

On behalf of the Sims Group USA Corporation (Sims)—and in accordance with the Consent Decree between the United States Environmental Protection Agency (EPA) and Sims, Case 3:14-cv-04209, dated September 15, 2014 (N. D. Ca. C14-4209) and effective December 1, 2014 ("the Consent Decree"(US District Court 2014))—Windward Environmental LLC (Windward) has prepared this ecological risk assessment (ERA) and an evaluation of the potential environmental impacts caused by disturbance of impacted sediment. This ERA has also been prepared in accordance with applicable risk assessment guidance and policies (EPA 1997, 1998; California DTSC 1996).

This evaluation addresses sediments in the immediate vicinity of Wharf 3 at the Port of Redwood City, a stretch that is composed of a riprap area and a subtidal area. Both areas are in an industrial waterway and are subject to current and future industrial use. The area evaluated by this ERA (hereafter referred to as the Project Area) is approximately 100 ft wide by approximately 325 ft long.

The goals of this evaluation were:

- Develop an ecological conceptual site model (CSM) of the riprap and subtidal areas.
- Evaluate the potential for the exposure of ecological receptors and compare to effects thresholds to characterize potential risks.
- Use, to the extent possible, similar ERA analyses from the San Francisco Bay area as a basis for assumptions or receptors.

The remainder of this ERA is organized as follows, consistent with appropriate guidance:

- Section 2 presents the site description and environmental setting.
- Section 3 presents the ecological CSM.
- Section 4 presents the evaluation of potential risks to the benthic invertebrate community.
- Section 5 presents the wildlife exposure and effects assumptions used for risk characterization.
- Section 6 presents the wildlife risk characterization and uncertainty assessment.
- Section 7 summarizes the ERA conclusions.
- Section 8 presents an evaluation of the environmental impacts that could potentially result from the disturbance of impacted sediments.
- Section 9 presents references.

Data and methods from another industrial site in San Francisco Bay were used to inform the methods and assumptions for this assessment. The Yosemite Slough site (EPA and E&E 2013) had similar receptors and polychlorinated biphenyls (PCBs) and metals in sediment, so the methods and assumptions used in the development of US Environmental Protection Agency (EPA)-approved ecological assessments for the Yosemite Slough site were used herein. These methods and assumptions were, in turn, based on the approach used at the adjacent Parcel F (offshore sediments) of the Hunters Point Shipyard site (Battelle et al. 2005).

2 Site Description and Environmental Setting

2.1 General Setting and Habitat

As described in detail in the final sediment investigation report (Terraphase 2018), Sims operates a metal-recycling facility (hereafter referred to as the Sims Facility) located at the Port of Redwood City (Port) in San Mateo County, California. The Project Area evaluated in this document represents a small area within Redwood Creek along an active industrial waterfront. The Project Area, which is adjacent to the Sims Facility, encompasses both subtidal and riprap/intertidal estuarine sediments (Figure 2-1). Redwood Creek is part of San Francisco Bay and is used for many purposes, including: industrial, waterfront residential, marina, recreational, open space, and institutional uses (EKI 2016). Port facilities along the eastern shoreline of Redwood Creek include several shiploading wharves, docks, and piers. However, the Project Area is an industrial use area and is expected to remain so in the future. Redwood Creek is dredged on a regular basis to maintain the navigation channel of -30 ft mean lower low water (MLLW) to allow for large vessel access at the wharves (ESA 2017).

The Project Area is a very small area, measuring approximately 0.6 acres, along Wharf 3 (Figure 2-1). It should be noted that the Project Area is much smaller than both the Yosemite Slough site (approximately 9 acres) (EPA and E&E 2013) and Parcel F (i.e., low-volume footprint areas) of the Hunters Point Shipyard site (approximately 42 acres) (Battelle et al. 2005) (Figure 2-2). The 0.6-acre Project Area is also quite small relative to nearby habitat, representing less than 1% of the intertidal and subtidal areas of Redwood Creek (approximately 239 acres) (Figure 2-3).

For purposes of the ERA, the Project Area was divided into two exposure evaluation units: the upper riprap unit and the lower riprap/subtidal unit. The differentiating characteristic between the two units is how accessible they are to potential foraging wildlife receptors. Consequently, the two units are considered separately.

- The upper riprap unit is covered by large rocks, with limited physical access to the underlying sediments. Therefore, the upper riprap unit represents very low-quality ecological habitat and, from an exposure pathway perspective, a *de minimis* pathway for ecological receptors. Therefore, this unit was not included in the ERA as part of the ecological exposure area.
- The lower riprap/subtidal unit consists of the lower portion of the riprap-covered slope, where the rock covering is less dense than in the upper riprap unit, and a subtidal portion between the lower riprap and Wharf 3 (Figure 2-1). In the lower riprap, where rocks are more widely interspersed than in the upper riprap unit, there is adequately accessible sediment. Therefore, from an exposure standpoint, the lower riprap is more similar to the subtidal area. Collectively, the lower riprap/subtidal unit—while representing negligible habitat relative to that available in nearby areas in the bay—does

have a potentially complete ecological exposure pathway. Therefore, this unit was evaluated quantitatively as the ecological exposure area.

These two units are discussed in more detail under the CSM description (Section 3).

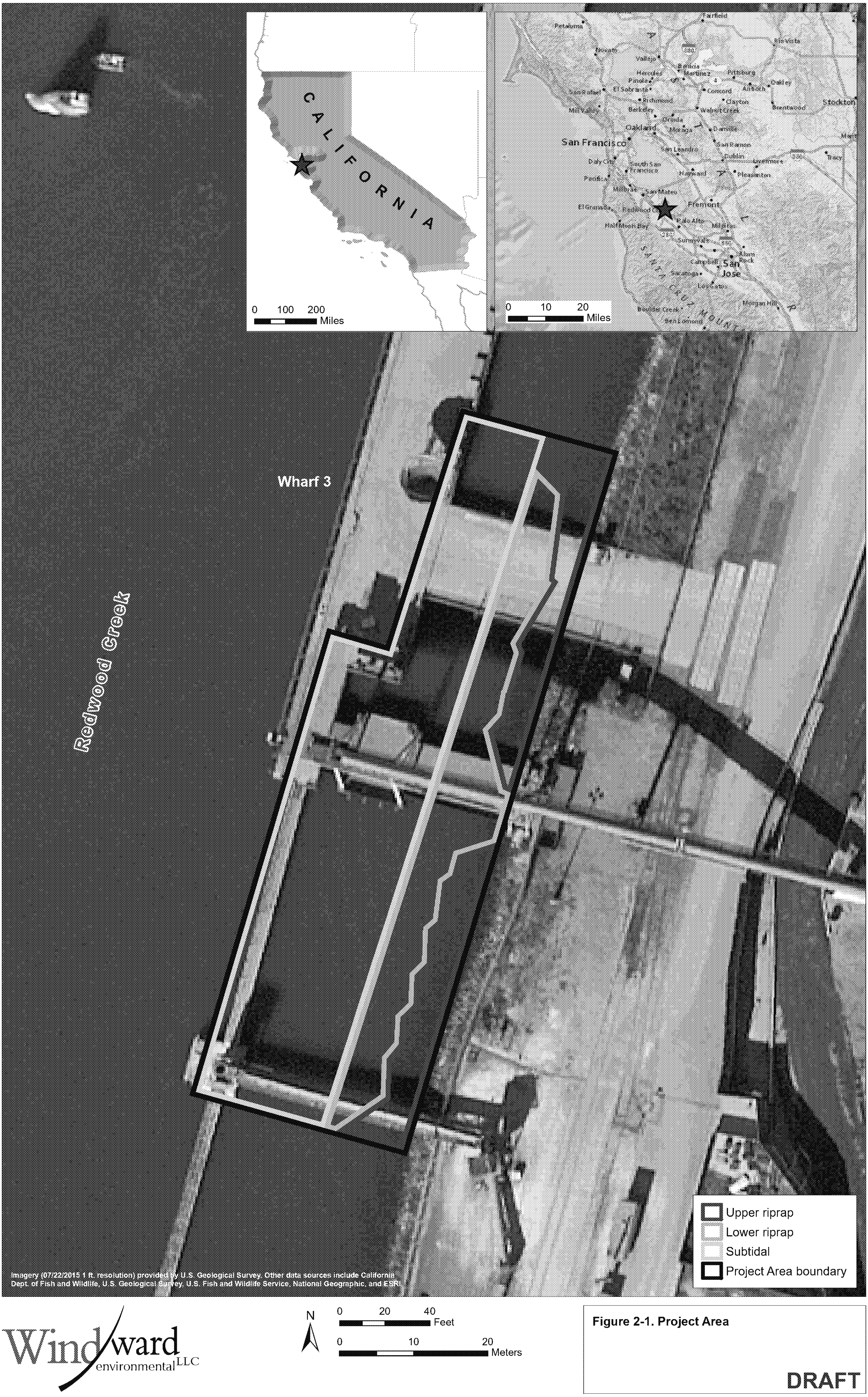

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Figure 2-1. Project Area

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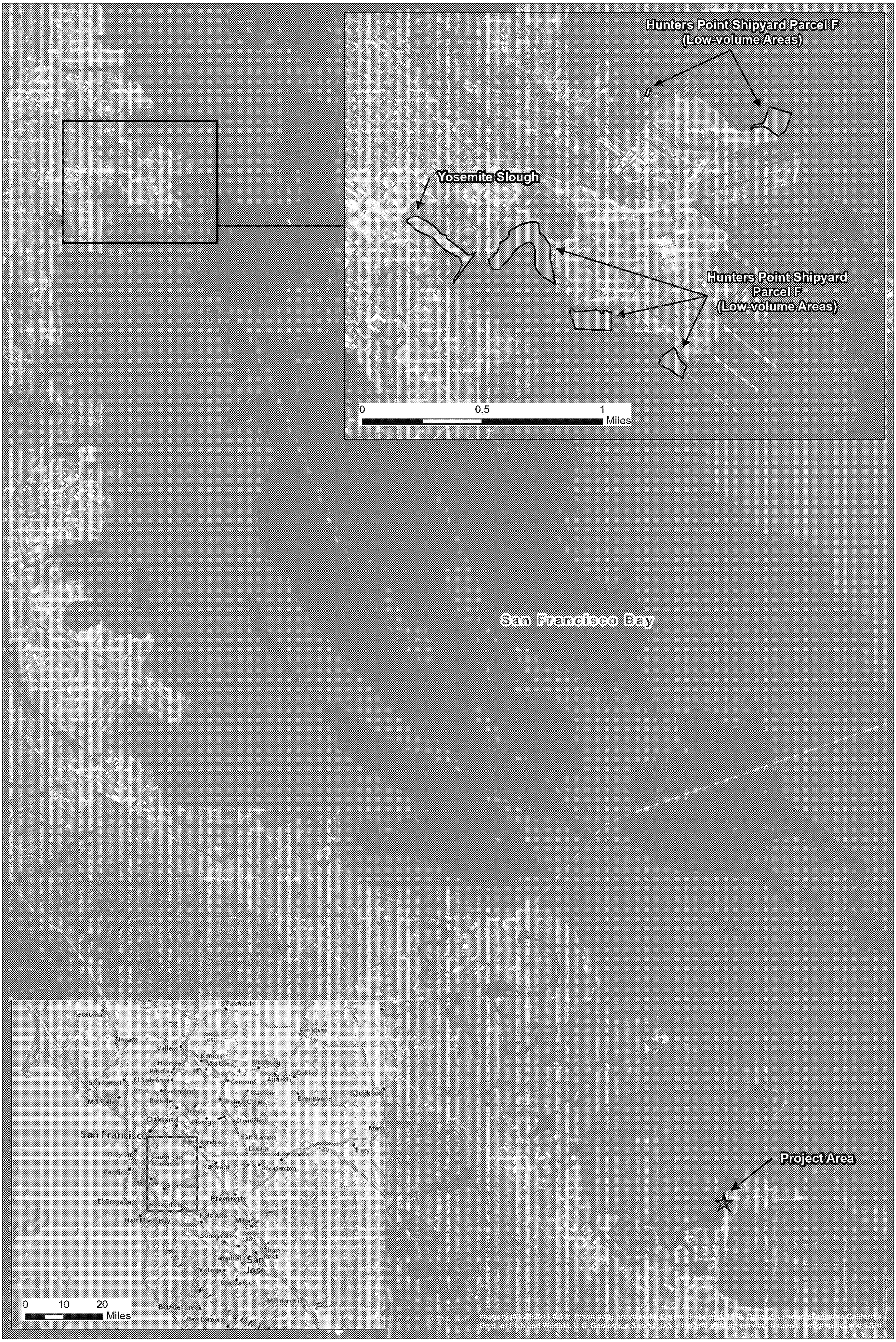

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Figure 2-2. Project Area and vicinity

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Name	Acres
Greco Island	786.2
Bair Island Ecological Reserve	1,931.8
Steinberger Slough	304.8
Redwood Creek	239.0
Project Area	0.6

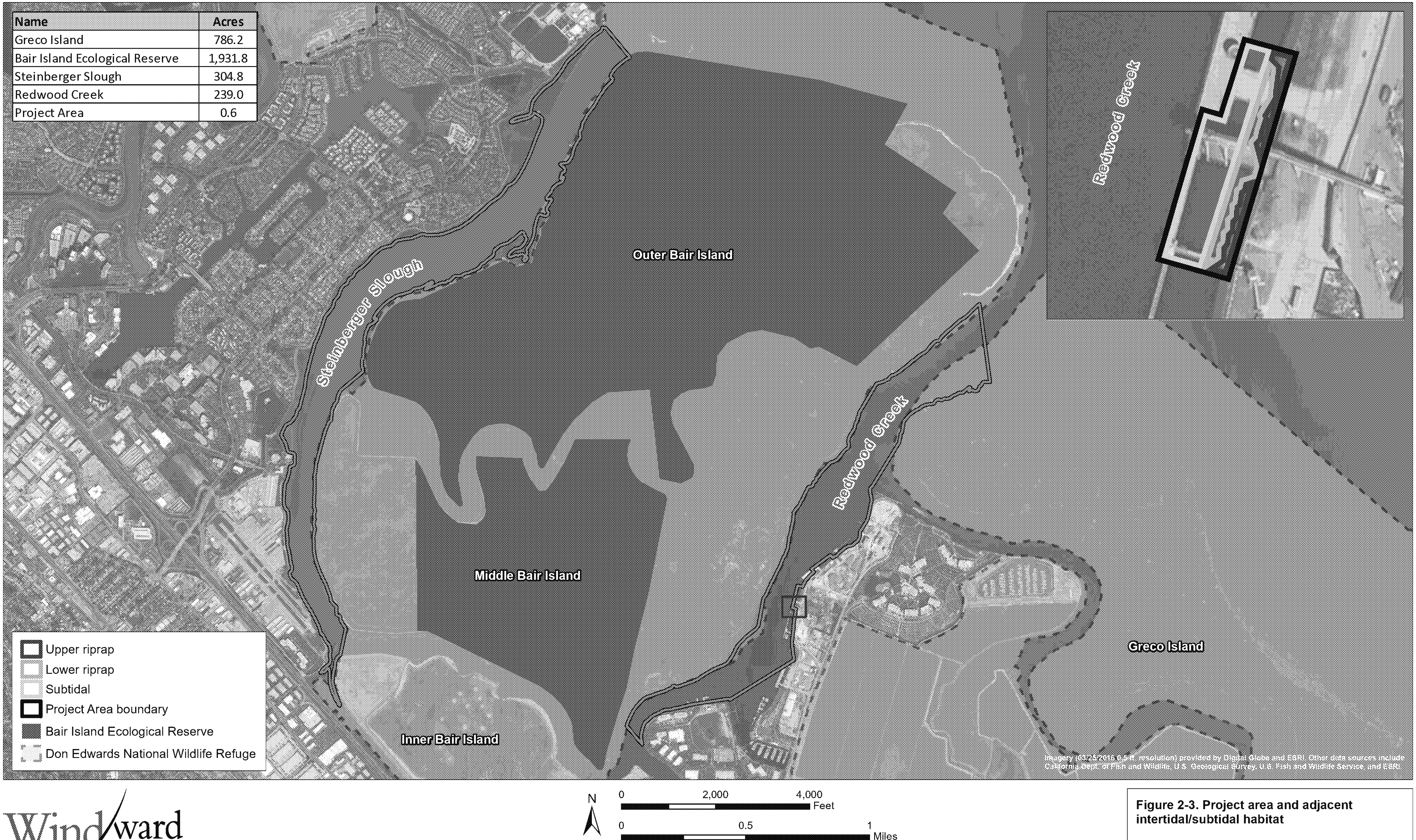

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Figure 2-3. Project area and adjacent intertidal/subtidal habitat

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2.2 POTENTIAL ECOLOGICAL HABITAT IN PROJECT AREA AND VICINITY

Information regarding the potential ecological habitat within the Project Area is important to understand in the development of the site-specific ecological CSM (Section 3). The Project Area does not support high-quality wildlife habitat due to its current industrial uses (ESA 2017). The Port completed an environmental description of the Project Area as part of a fender replacement project and described the habitat as industrial. As stated in the Port's permit application, the Project Area is designated Industrial-Port Related by the City of Redwood city general plan and is zoned General Industrial (ESA 2017). Any previously existing tidal flats, typically used by foraging birds, have been removed to make room for current industrial uses (ESA 2017). The abundance and diversity of fish, aquatic organisms, and wildlife is lower than that at the nearby Bair Island Ecological Reserve and Don Edwards San Francisco Bay National Wildlife Refuge (NWR) (Figure 2-3) (ESA 2017).

2.2.1 Project Area

Aquatic habitat types in the vicinity of the Project Area include shallow bay and subtidal (channel), tidal flat, and rocky shore (riprap) areas (ESA 2017). While tidal flats are not present in the Project Area, having been replaced with shoreline structures or removed by channel dredging within Redwood Creek, this habitat does occur northwest of the Project Area in the Don Edwards San Francisco Bay NWR (ESA 2017).

The sediments in the subtidal area are generally composed of clay and silts and support the presence of a benthic invertebrate community (ESA 2017). Rocky riprap is present along the reinforced shoreline of the Project Area. While riprap may provide some habitat to epibenthic organisms, such as mussels (*Mytilus* sp.), barnacles, and rock crabs (*Cancer antennarius and C. productus*) (ESA 2017), a robust infaunal benthic community is not expected to be present and available as prey, given the isolated nature of the pockets of sediment.

Figures 2-4a through 2-4c show the general shoreline along the Project Area.

Figure 2-4a. Redwood Creek Project Area Photo A

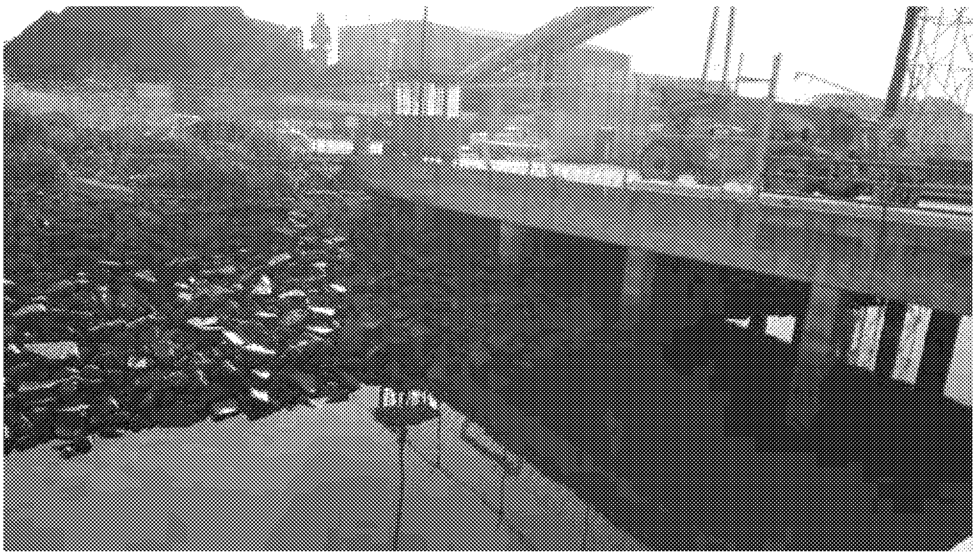

Figure 2-4b. Redwood Creek Project Area Photo B

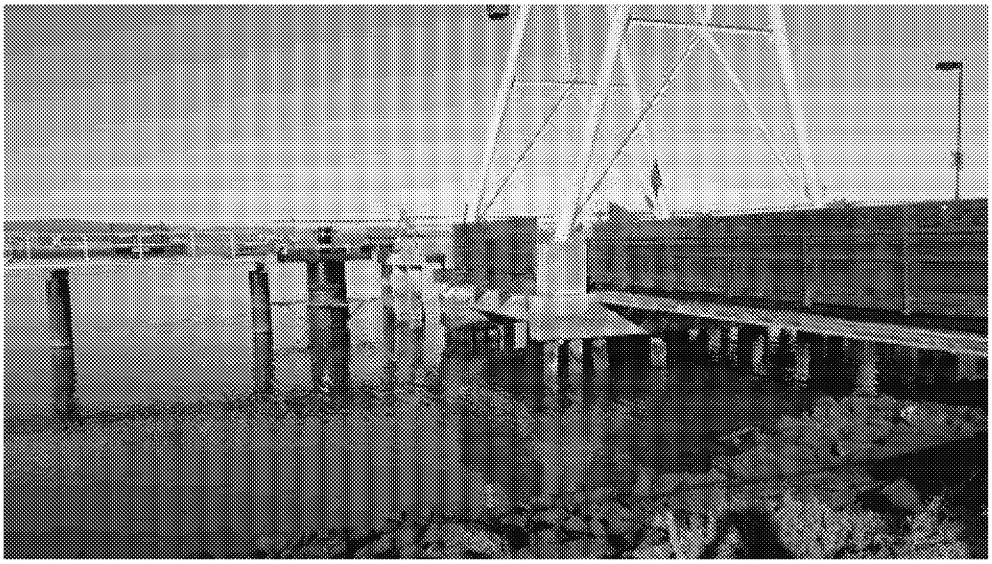

Figure 2-4c. Redwood Creek Project Area Photo C

2.2.2 Nearby habitat

The size of the Project Area relative to that of the intertidal marsh habitat areas on nearby Bair and Greco Islands is less than 0.1%. Bair Island is actually three islands (Inner, Middle, and Outer) totaling approximately 3,200 acres (Figure 2-3). Historically, Bair Island was used for salt evaporation ponds, but the ponds were drained in 1965. Since 1986, a portion of Bair Island has been designated as an ecological reserve (CDFW 2017). Approximately 2,000 acres of Middle and Outer Islands are within the Bair Island Ecological Reserve, and approximately 1,000 acres are part of the larger Don Edwards San Francisco Bay NWR. A restoration plan that was completed in 2006 has been implemented to restore Bair Island to intertidal salt marsh habitat (USFWS 2006, 2012).

Greco Island, located northeast of the Project Area, is approximately 800 acres and consists of intertidal marsh habitat (Figure 2-3). Nearly half of Greco Island was developed into salt works in the early 1900s. By the late 1950s, all of the historical salt works had reverted to intertidal marsh (USFWS 2012). The bay side of Greco Island contains the largest area of relatively undisturbed historical intertidal marsh in the southern portion of San Francisco Bay (USFWS 2012).

The habitat areas around Bair and Greco Islands are composed of more desirable foraging habitat for wildlife than that available within the limited footprint of the industrial Project Area.

3 Ecological Conceptual Model

The following section presents the overall ecological CSM for the Project Area. As noted, ecological evaluations completed for nearby, larger but similar (albeit less industrial than the Port of Redwood City) sites (Yosemite Creek and Hunters Point Shipyard) were consulted to ascertain if similar receptors and exposure pathways could be used for this ERA. Site-specific information on habitat quality and quantity was derived from available site-specific studies (EKI 2016; ESA 2017). The CSM is critical in the development and selection of relevant receptors and exposure pathways for an appropriate risk evaluation (EPA 1997, 1998; California DTSC 1996). For this ERA, the CSM was used to determine whether constituents in the sediment could adversely impact potential ecological receptors from complete exposure pathways.

3.1 Potential Ecological Receptors

Wildlife species utilizing the Project Area are expected to be similar to those noted in the Yosemite Slough site ERA; however, the Project Area has more freshwater influence and no significant emergent vegetation. While limited in the Project Area, it and the vicinity within Redwood Creek do provide wildlife habitat for some species, including: western grebe (*Aechmophorus occidentalis*), canvasback (*Aythya valisineria*), surf scoter (*Melanitta perspicillata*), ruddy duck (*Oxyura jamaicensis*), and Forster's tern (*Sterna forsteri*). Some mammals, such as harbor seal (*Phoca vitulina*) and California sea lion (*Zalophus californianus*), may be present in the vicinity of the Project Area (EKI 2016; ESA 2017), but use of the Project Area by wildlife is quite limited relative to other areas in and near Redwood Creek. No significant use by threatened and endangered wildlife species was found at the Project Area (ESA 2017).

A limited benthic community is expected in the subtidal surface sediment of the Project Area and, to some extent, in the lower riprap sediment. The Project Area is within the mesohaline environment of San Francisco Bay (Thompson et al. 2013), and the benthic community within the Project Area is expected to be consistent with those in other locations within the mesohaline environment. Mesohaline benthic communities are primarily represented by amphipods, polychaetes, oligochaetes, and bivalves, taxa that represent different feeding strategies (Table 1) (Nichols and Thompson 1985; Thompson et al. 2013). The most common benthic taxa are the amphipods *Ampelisca abdita* and *Monocorphium acherusicum*, the polychaete *Streblospio benedicti*, the bivalves *Potamocorbula amurensis* and *Gemma gemma*, and the oligochaetes *Tubificid sp.* (Thompson et al. 2013). Because Redwood Creek is an active shipping channel and the Project Area is industrial, the benthic community is not expected to be as robust as would be expected in a non-industrial area.

Table 3-1. Representative taxa found in San Francisco Bay mesohaline environments

Taxa Group	Representative Species	Feeding Strategy
Amphipods	*Ampelisca abdita, Monocorophium acherusicum, Grandidierella japonica, Corophium spp.*	tube-dwelling filter feeder, surface-feeding detritivore
Polychaetes	*Streblospia benedicti, Heteromastus filiformis, Glycinde sp., Asychis elongate, Polydora sp.*	surface-feeding detritivore, filter feeders
Oligochaetes	*Tubificidae sp.*	head-down deposit feeders
Bivalves	*Potamocorbula amurensis, Corbula amurensis, Gemma gemma, Macoma balthica, Mya arenaria*	surface filter feeders

Sources: Thompson et al. (2013); Nichols and Thompson (1985),Nichols and Pamatmat (1988); EPA (2015).

3.2 Sediment Exposure Depth

Given the feeding mode of most of the benthic invertebrates that are representative of mesohaline benthic communities in San Francisco Bay, it is expected that the biologically active zone (BAZ) will be limited largely to the upper few centimeters of the sediment surface where these representative species live. That the majority of the benthic community resides in the upper few centimeters is not uncommon. De La Cruz et al. (2017), in their study of the density of benthic invertebrate communities based on depth from the sediment surface, found that the majority of benthic invertebrates are located in the upper 2 cm. The authors observed that most of the benthic species were found at a shallow depth, regardless of whether the benthic community was undisturbed (stable environment) or was recovering from disturbance (recovery following a dredging event). These observations are similar to the guidance provided by EPA (2015) on determining the appropriate depth of sediment to use when conducting ERAs. EPA recommends that a risk assessment be conducted on sediment collected to a depth that represents the 80th percentile distribution of the abundance of the benthic community at the site. Using the information provided in Figure 3 of the guidance document (EPA 2015), the mean depth expected for the mesohaline benthic community found at Redwood Creek is between approximately 5 and 7 cm (for mesohaline mud and mixed mud and sand substrates, respectively). Biomass that is present deeper than 15 cm is expected to be mostly a low density of bivalves that filter feed at the surface, limiting their exposure to deep sediments. Accordingly, surface sediment collected from 0 to -15 cm (0.0 to -0.5 ft) was used to evaluate the potential exposure of ecological receptors. While there are sediments at depth (below the BAZ) with elevated constituent concentrations (Terraphase 2018), benthic invertebrate community exposure to sediments below 15 cm is not expected.

3.3 Potential Ecological Exposure Pathways

As described, based on the potential for ecological exposure, the Project Area sediment was divided into two units for the ecological CSM: lower riprap/subtidal unit and upper riprap unit (Figure 3-1). Whereas upper riprap unit is covered with a substrate (rocks), surface sediments are available for exposure in the lower riprap/subtidal unit.

The potential for ecological receptors to be exposed to sediment in each of these units is defined as follows:

- **Lower riprap/subtidal unit sediment** – Diving ducks or other avian species have the potential, albeit infrequently, to be exposed to subtidal sediment and riprap sediment within the lower portion of the riprap area when it is inundated; exposure could occur either directly or indirectly through benthic prey present in the sediment. This unit was evaluated quantitatively as the ecological exposure area.
- **Upper riprap unit sediment** – Based on the information provided by ESA (2017), this rocky riprap is considered an exposure barrier for the majority of ecological receptors that use sediment for probing or foraging. While the upper riprap sediment likely serves as a temporary rest area, it provides an insignificant foraging area for any complete exposure pathway from the small pockets of sediment in between the large rock slabs to wildlife receptors. Furthermore, given the small areal extent of the Project Area, any ecological exposure to small pockets of surface sediments within the upper riprap unit is likely to be *de minimis* and therefore considered insignificant. Therefore, this unit was not included in the ERA as part of the ecological exposure area.

Figure 3-2 presents the ecological CSM for the Project Area, including the potential ecological exposure pathways. This assessment focuses on the potential exposure of ecological receptors to sediment within the lower riprap/subtidal unit. As discussed in Section 3.2, exposure to surface sediment is limited to the BAZ, which is expected to exist within the top 15 cm only.

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N

0 20 40 Feet

0 10 20 Meters

Figure 3-1. Sediment sample locations in the ecological exposure area

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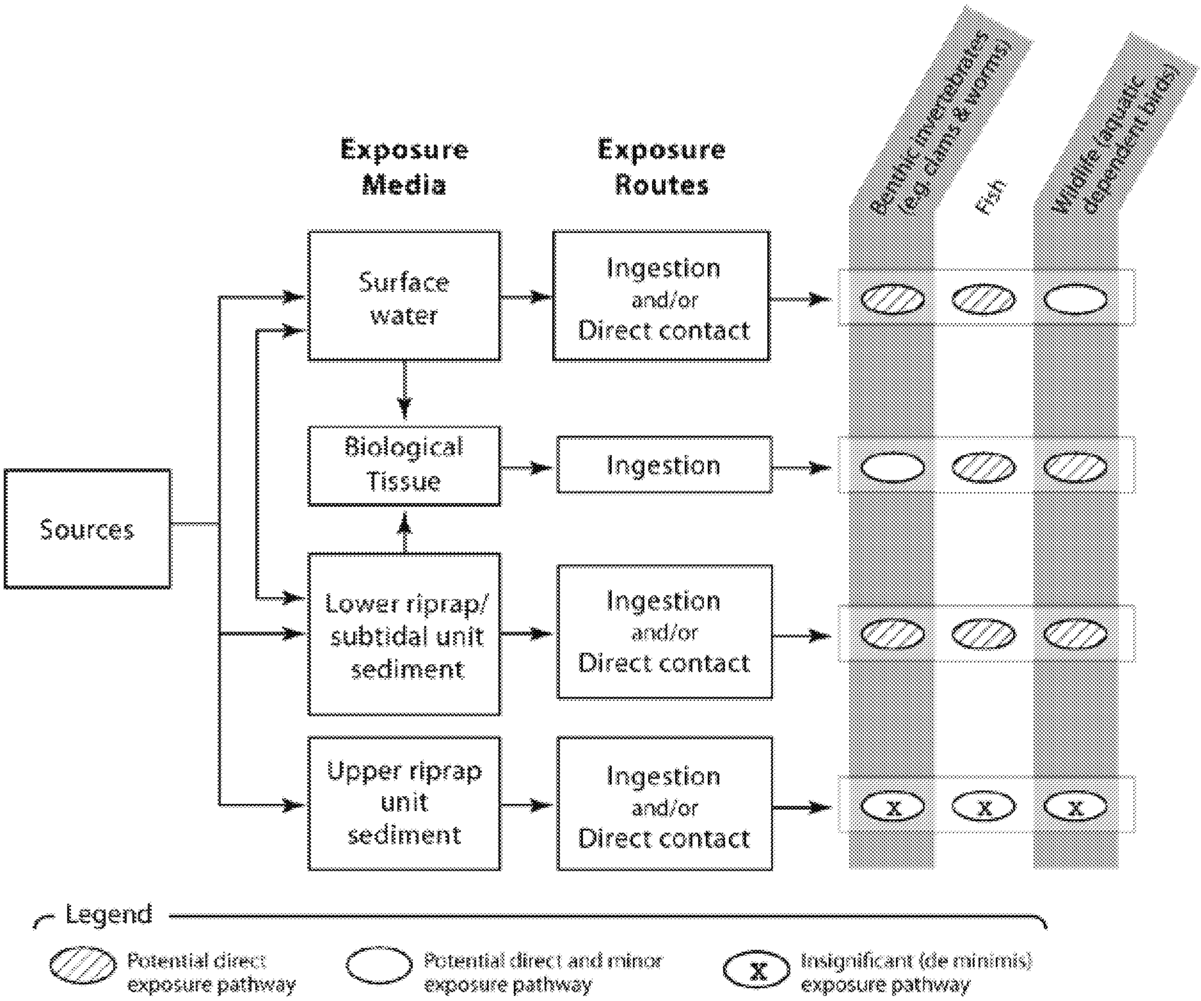

Figure 3-2.Ecological conceptual site model

3.4 SELECTED ECOLOGICAL RECEPTORS

The specific ecological receptors selected for evaluation in this ERA represent maximum exposure scenarios, consistent with ERA guidance (EPA 1997; California DTSC 1996).

3.4.1 Benthic invertebrates

The benthic invertebrate community is not expected to be as robust as that in a non-industrial area, as described above. However, the potentially existing benthic community in the surface sediment of the lower riprap/subtidal unit within the Project Area was evaluated for this ERA for completeness. Details on the benthic invertebrate community expected to be present are discussed in Section 3.1. The assessment of potential risks to this receptor group is provided in Section 4.

3.4.2 Wildlife

The lesser scaup (*Aythya affinis*) was selected as a representative benthic invertebrate-eating, site-specific, wildlife receptor. The exposure pathway for that species represents a maximum exposure scenario, based on its feeding strategy and availability within the larger San Francisco Bay area. Scaup in San Francisco Bay have adapted to feed primarily on the highly abundant clam *P. amurensis* (Poulton et al. 2002), which is expected to be present in the mesohaline mud subtidal habitats at and near the Project Area (Thompson et al. 2013). Scaup were considered more representative of benthic invertebrate-eating aquatic birds than surf scoter (the benthic invertebrate-eating receptors selected for Hunters Point Shipyard site), because previous bird surveys conducted near the Project Area have indicated that scoter is uncommon in the vicinity (Richmond et al. 2014). Although surf scoter could be present in the area in the winter, their presence would be limited to the open-water areas of San Francisco Bay (i.e., outside of Redwood Creek) (Richmond et al. 2014). In addition, surf scoter have been shown to respond to ephemerally abundant food sources, like herring spawn or polychaete worms, making them less appropriate to represent benthic invertebrate-eating receptors (Lacroix et al. 2005).

Great blue heron was identified as a potential fish-eating bird receptor, since that species is ubiquitous and commonly uses mudflat areas such as those in the Project Area. However, their diet comprises primarily fish (as well as small portions of amphibians and small birds and mammals), so any exposure to Project Area sediment (directly or indirectly through their prey) would be expected to be minimal, especially relative to the exposure of the lesser scaup. Therefore, great blue heron was not evaluated as a wildlife receptor associated with a significant pathway for exposure at the site. This is consistent with the approach taken for the Hunters Point Shipyard site, where the ERA focused on surf scoter rather than double-crested cormorant (a fish-eating aquatic bird receptor); the smaller home range of the scoter made it a more appropriately representative species (Battelle et al. 2005).

The lesser scaup, consistent with EPA guidance (EPA 1997, 1998; California DTSC 1996), represents the maximally exposed receptor. Therefore, as is typically done in the problem formulation phase of an ERA, the species is representative of other ecological receptors in that area (such as those listed in Section 3.1). Scaup was selected over other potentially present duck species, such as a canvasback, because such species are more omnivorous, and exposure is expected to be greater when the receptor consumes invertebrates, since plants are very limited in the Project Area. The exposure of fish-eating birds was also expected to be less than that of scaup; fish are exposed to sediment over a much larger region than just the Project Area, and the range of fish-eating birds is substantially greater than the Project Area (e.g., the foraging range of double-crested cormorants nesting at the San Francisco-Oakland Bay Bridge was estimated as 227 km^2 [approximately 56,100 acres] (Battelle et al. 2005).).

4 Risk Evaluation of Benthic Invertebrate Community

The probability of risk to the benthic community was assessed using the site-specific surface sediment data available for the lower riprap/subtidal unit, as well as regional toxicity and benthic community data for similar mesohaline habitats in San Francisco Bay, including other areas of Redwood Creek. A summary of this assessment is presented in this section, and additional details are provided in Appendix A.

Metals and PCB concentrations in lower riprap/subtidal unit surface sediment (Terraphase 2018) exceed effects range - median (ERM) values; however, ERM values should not be used to predict effects in risk assessments (Long and Morgan 1990; Long et al. 1995; MacDonald et al. 1996). Regional data support the lack of a relationship between ERM exceedances and adverse effects on the benthic invertebrate community. In fact, the regional sediment toxicity data and regional benthic community data suggest that there is minimal risk to benthic populations within the lower riprap/subtidal unit:

- Although ERM exceedances were observed, no toxicity to amphipods (*Eohaustorius estuaries*) and only limited toxicity to urchin larvae (*Stronglyocentrotus purpuratus)* was observed at the Hunters Point Shipyard site, based on laboratory toxicity tests using site sediment (Battelle et al. 2005). Furthermore, toxicity results for both species indicated no dose-response relationship for sediment chemistry and no relationship between actual toxicity response and predicted toxicity response based on exceedances of ERM values, either as individual ERMs or ERM quotient (ERMq) values.
- No relationship was found between benthic species richness or *Ampelisca abdita* abundance and ERMq values based on data collected within the south bay mesohaline area of San Francisco Bay, including one sediment site located in Redwood Creek (SCCWRP 2010).
- The City of Redwood City reported that sediment concentrations within Redwood Creek just upstream of the Project Area were found to be greater than ambient values and ERMs; however, the concentrations were found to not be detrimental to benthic organisms based on the bioavailability of contaminants (EKI 2016).

5 Wildlife Exposure and Effects Evaluation

The analysis of exposure and effects prior to risk characterization is consistent with ERA guidance (EPA 1997, 1998; California DTSC 1996). As stated, this ERA focuses on the maximum exposure scenario and receptor(s), and attempts to be consistent with other proximal ERAs with similar scenarios, receptors, and constituents. Since the Yosemite Slough site and its receptors, pathways, and constituents were similar to those of the Project Area, and the risk assessment was completed and accepted by regulatory authorities (EPA and E&E 2013), the Yosemite Slough site was used as a basis for the Redwood City ERA. The derivation of assumptions and methods for the Yosemite Slough site was documented in the *Hunters Point Shipyard Parcel F Validation Study Report* (Battelle et al. 2005). For consistency, a similar method was adopted to evaluate the Project Area and is documented in the following subsections:

- Section 5.1 – Identifies which constituents were evaluated (constituents of concern) (COCs)
- Section 5.2 – Identifies the dietary exposure assumptions and biota accumulation factors (BAFs) used to model prey tissue
- Section 5.3 – Identifies the toxicity reference values (TRVs) for COCs

5.1 COCs Evaluated

Project Area sediment was characterized by determining concentrations of metals and PCBs, as presented in Terraphase (2018). The dataset included data from the 48 surface (0 to 15 cm) sediment samples from the lower riprap/subtidal unit (subtidal area includes 35 samples and lower riprap area includes 13 samples), the ecologically relevant exposure area as described in the CSM (Figure 3-1). The upper riprap unit, as discussed in the CSM, was not quantitatively evaluated (i.e., was not included in the ecological exposure area) because it is considered an insignificant ecological pathway.

Metals that were infrequently detected (Terraphase 2018) were not included in this ERA; this included selenium and thallium (Table 5-1). In addition, the following metals were not evaluated because the forms of these elemental and essential metals available in the environment are not expected to be toxic to ecological receptors: aluminum, barium, and iron.

Table 5-1. Summary of constituents analyzed in surface sediments

Constituent	Detection Frequency in Ecological Exposure Area (Lower Riprap/Subtidal Unit)		Constituent Included in ERA Evaluation?
	No. Detects/No. Samples	Detection Frequency	
Aluminum	48/48	100%	no; not expected to be toxic
Antimony	15/48	31.3%	yes
Arsenic	48/48	100%	yes

Constituent	Detection Frequency in Ecological Exposure Area (Lower Riprap/Subtidal Unit)		Constituent Included in ERA Evaluation?
	No. Detects/No. Samples	Detection Frequency	
Barium	48/48	100%	no; not expected to be toxic
Beryllium	46/48	95.8%	yes
Cadmium	42/48	87.5%	yes
Chromium[a]	48/48	100%	yes
Cobalt	48/48	100%	yes
Copper	48/48	100%	yes
Iron	48/48	100%	no; not expected to be toxic
Lead	48/48	100%	yes
Mercury	47/48	97.9%	yes
Molybdenum	28/48	58.3%	yes
Nickel	48/48	100%	yes
Selenium	10/48	20.8%	no; low detection frequency
Silver	44/48	91.7%	yes
Thallium	3/48	6.3%	no; low detection frequency
Vanadium	48/48	100%	yes
Zinc	48/48	100%	yes
Total PCBs	48/48	100%	yes

[a] Chromium is defined as the sum of chromium III and chromium VI.
ERA – ecological risk evaluation
PCB – polychlorinated biphenyl

5.2 EXPOSURE ASSESSMENT

In the exposure assessment, dietary doses for scaup based on exposure within the lower riprap/subtidal unit were estimated based on ingestion of biota (i.e., prey) and incidental ingestion of sediment. Dietary doses were estimated as milligrams of each constituent ingested per kilogram of body weight per day (mg/kg bw/day) using the following equation:

$$Dose = \frac{\left[(FIR \times C_{prey}) + (SIR \times C_{sed})\right]}{BW} \times SUF$$

Equation 5-1

Where:

Dose = daily ingested dose (mg/kg bw/day)
FIR = food ingestion rate (kg ww/day)
C_{prey} = concentration in prey tissue (mg/kg ww); C_{prey} was estimated using C_{sed} and biota accumulation factors (BAFs)
SIR = incidental sediment ingestion rate (kg dw/day)

C_{sed} = concentration in lower riprap/subtidal unit surface (0–0.5 ft) sediment (mg/kg dw), represented by the 95 UCL[1]
BW = body weight (kg)
SUF = site use factor (unitless)

Exposure assumptions and BAFs used to model prey tissue concentrations are presented in the following subsections.

5.2.1 Exposure assumptions

The selected body weights, ingestion rates, and dietary compositions of lesser scaup are presented in Table 5-3. These parameters are discussed in detail in the following subsections.

Table 5-3. Summary of bird exposure parameter assumptions

Exposure Parameter	Lesser Scaup	
	Value	Source
Body weight (kg)	0.815	EPA (1993)
FIR (kg/d dw)	0.0629	Nagy (2001)
SIR (kg/d dw)	0.0030	4.7% FIR (Beyer et al. 2008)
Diet	100% inverts	EPA (1993); Anteau et al. (2014)
Foraging range	220 ac (89 ha)	EPA (1993)
SUF	0.03; 0.003	details on SUF assumptions presented in text below

EPA – US Environmental Protection Agency FIR – food ingestion rate SIR – sediment ingestion rate

5.2.1.1 Body weight

The lesser scaup's body weight of 0.815 kg was based on the average male and female data reported for the United States in EPA's *Wildlife Exposure Factors Handbook* (EPA 1993).

5.2.1.2 Food ingestion rate

A food ingestion rate (FIR) of 0.0629 kg dry weight (dw)/day was derived based on the allometric equation derived for all birds (Nagy 2001), wherein:

$$FIR = 0.638 \times BW^{0.685}$$ **Equation 5-2**

Where:

FIR = food ingestion rate (kg dw/day)
BW = body weight (g)

[1] Upper confidence limit (UCL) concentrations used to represent exposure point concentrations (EPCs) were calculated using EPA's ProUCL® statistical package (Version 5.1.00) (EPA 2016) and were derived following EPA guidance for calculating UCLs for EPCs at hazardous waste sites (EPA 2002a).

5.2.1.3 Sediment ingestion rate

An incidental sediment ingestion rate (SIR) of 0.0063 kg dw/day was derived by assuming that lesser scaup incidentally ingested sediment at up to 4.7% of the FIR. This assumption was based on an incidental SIR for lesser scaup reported by Beyer et al. (2008).

5.2.1.4 Diet

While the diet of the lesser scaup is predominately aquatic benthic invertebrates such as insects, crustaceans, and mollusks, scaup may also consume some portion of vegetation and fish (EPA 1993; Anteau et al. 2014). For modeling, 100% ingestion of benthic invertebrates was assumed for this assessment. The assumption that the scaup diet is 100% invertebrates limits the species' potential for exposure to location-specific sediment (since benthic invertebrates are immobile or have very limited mobility compared to fish), and the presence of vegetation within the lower riprap/subtidal unit is lacking.

5.2.1.5 Site use factor

It is critical to establish a reasonable site use factor (SUF) for selected ecological receptors to accurately characterize their potential exposure at a given site. It is especially critical at the Project Area, given the very small size of the site. The home range, particularly the foraging areas within the home range, and movement patterns of a species, are important in determining whether exposure areas are representative of actual exposure (EPA 1998). Several factors can be considered when determining an appropriate SUF:

- Foraging range/home range of receptor – EPA (1993) cites a mean minimum foraging home range of 89 hectares (220 acres) for lesser scaup.
- Area of the site relative to nearby similar- or higher-quality habitat – The Project Area represents a small footprint of ecological habitat within the home range of scaup, which also includes other portions of Redwood Creek and nearby high-quality habitats at Bair and Greco Islands and Stienberger Slough (Figure 2-3).

Table 5-4 summarizes the size of the Project Area relative to the home range reported for lesser scaup and relative to nearby intertidal and subtidal habitat and potential SUFs based on these values. Also important to note is the relative size of the Project Area (0.6 ac) compared to the Hunters Point Shipyard site (i.e., the defined "low-volume footprint areas" totaling 42 ac) (Figure 2-2) (Battelle et al. 2005); the Project Area is 1% of the area of the Hunters Point Shipyard site.

Table 5-4. Summary of spatial areas used in determining the SUF for lesser scaup

<table>
<tr><th>Area</th><th>Size (acres)</th><th>Potential SUF</th><th>Notes</th></tr>
<tr><td>Project Area</td><td>0.6</td><td>na</td><td>na</td></tr>
<tr><td>Lesser scaup breeding home range (EPA 1993)</td><td>220</td><td>0.003</td><td>size of Project Area (0.6 ac) divided by size of lesser scaup breeding home range (220 ac)</td></tr>
<tr><td>Redwood Creek subtidal/intertidal area (Battelle et al. 2005)</td><td>239</td><td rowspan="4">0.003–0.0003</td><td rowspan="4">size of Project Area (0.6 ac) divided by size of individual nearby habitat areas</td></tr>
<tr><td>Steinberger Slough subtidal/intertidal area</td><td>305</td></tr>
<tr><td>Nearby intertidal habitat – Bair Island Ecological Reserve</td><td>1,932</td></tr>
<tr><td>Nearby intertidal habitat – Greco Island</td><td>768</td></tr>
</table>

na – not applicable
SUF – site use factor

Based on the information presented in Table 5-4, an SUF of 0.003 or less is appropriately reasonable. An SUF of 0.003 assumes that when present in the vicinity, lesser scaup will spend 0.3% of their time in the Project Area. In actuality, lesser scaup will spend even less time at the Project Area, given that they are not present in the region year-round; the species overwinters in San Francisco Bay and leaves the area to breed (Anteau et al. 2014). However, other benthic invertebrate-feeding birds at the site (such as ruddy duck or canvasback) may be present year-round.

An SUF one order of magnitude higher (SUF of 0.03) was also evaluated; this SUF assumes that when present, lesser scaup will spend 3% of their time foraging in the Project Area. The SUF of 0.03 overestimates by an order of magnitude a realistic use of the Project Area by an aquatic bird such as a lesser scaup, given the very small size of the site relative to the species' foraging range, and relative to other nearby available habitat. However, this SUF is included for conservatism and reference purposes.

5.2.2 Prey tissue modeling

BAFs were applied in order to determine prey (benthic invertebrate) tissue concentrations for the dietary assessment of wildlife. A BAF represents the ratio of tissue concentrations to sediment concentrations based on the following equation:

$$BAF = \frac{C_{tiss}}{C_{sed}}$$ **Equation 5-3**

Where:

BAF	=	biota accumulation factor
C_{tiss}	=	concentration in tissue (mg/kg dw)
C_{sed}	=	concentration in sediment (mg/kg dw)

BAFs were based on co-located regional-specific data collected from the Hunters Point Shipyard Parcel F site (Table 5-5). BAFs were based on either those presented in the validation study (Battelle et al. 2005), or on a similar, independently conducted analysis based on the raw co-located data. Invertebrate tissue BAFs at the Hunters Point Shipyard Parcel F site were derived for copper, mercury, and total PCBs. These BAFs were based on the ratio of co-located mean sediment concentrations to mean tissue concentrations of bent-nose clams (*Macoma nasuta*), which was derived from a 28-day bioaccumulation laboratory study of samples from 5 areas (Battelle et al. 2005). For all other metals considered in this evaluation, invertebrate tissue BAFs were derived by applying a similar method to the raw co-located sediment and depurated *M. nasuta* tissue data from the Hunters Point Shipyard Parcel F site: BAFs were determined as the mean co-located BAFs across the five low-volume footprint areas of Parcel F (Areas I, III, VIII, IX, and X) and reference sampling areas.

Table 5-5. Summary of invertebrate BAFs

Constituent	Invertebrate BAF[a]	Source
Antimony	0.17	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Arsenic	2.0	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Beryllium	1	no co-located data available from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005); default BAF of 1.0 used
Cadmium	1.1	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Chromium	0.056	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Cobalt	0.13	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Copper	0.22	as reported in Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Lead	0.12	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Mercury	0.53	as reported in Hunters Point validation study (Battelle et al. 2005)
Molybdenum	3.0	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Nickel	0.078	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Silver	0.93[b]	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Vanadium	0.057	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Zinc	0.79	derived using co-located sediment and tissue data from Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)
Total PCBs	2.0	as reported in Hunters Point Shipyard Parcel F validation study (Battelle et al. 2005)

[a] BAFs are the ratios of tissue concentrations to sediment concentrations, wherein both tissue and sediment are reported on a dry weight basis.

[b] For silver, detection frequency in sediment and tissue samples was less than 100%; BAFs in samples with non-detected values were derived based on detection limits.

BAF – biota accumulation factor

PCB – polychlorinated biphenyl

5.3 EFFECTS ASSESSMENT

To determine whether there is an adverse effect on wildlife, a TRV is developed as a threshold dose that may have deleterious effects on an individual of a particular species. Because ERAs are conducted at the population level, this use of individual measures of effects is considered an added layer of conservatism. Both lowest-observed-adverse-effect level (LOAEL) and no-observed-adverse-effect level (NOAEL) avian TRVs are presented in this section, as both are commonly used in ERAs in accordance with EPA guidance (1997). NOAELs signify conservative screening thresholds that represent the maximum dose at which *no effect* is observed. These thresholds are useful in ruling out the potential for risks to ecological populations when predicted doses at a site are less than NOAELs. While risk calculations based on NOAELs are presented, it is more appropriate to consider LOAELs when evaluating the potential for actual risk, as LOAELs are the lowest doses at which an adverse effect is observed.

NOAEL and LOAEL TRVs were developed based on review of toxicological literature. TRVs for this ERA were selected based on a comprehensive literature search and review and a systematic process to identify appropriate NOAEL and LOAEL TRVs for the protection of ecological receptors. Specifically, NOAEL and LOAEL TRVs were derived based on a review of primary toxicological studies. The list of studies reviewed is presented in Appendix B. Dietary TRVs were derived from those studies that best met the criteria for evaluating the potential for population-level risks to birds. These criteria included the following:

- TRVs are based on endpoints that directly measure survival, growth, or reproduction. Adverse effects on populations may be inferred or extrapolated from measures related to impairments of these endpoints (EPA 1997).
- TRVs are representative of NOAEL and/or LOAEL concentrations or doses. Both NOAELs and LOAELs commonly provide the basis for the TRVs used in ERAs in accordance with EPA guidance (EPA 1997, 1998).
- TRVs are derived from controlled toxicity studies that used standardized and/or peer-reviewed experiment methods, and in which a clear concentration- or dose-response relationship was reported.
- TRVs are based on the exposure of an organism to a single constituent or specific mixtures of related constituents (i.e., mixtures of constituents within the same class, such as PCBs).
- TRVs reflect a preferred dietary exposure route (EPA 1997).

- TRVs are not based on bioaccumulation studies. Bioaccumulation studies that report only corresponding uptake and bioaccumulation and do not measure effects on specific endpoints are not useful for the derivation of TRV.
- Unless no other data are available, TRVs are not based on egg productivity or other reproductive endpoints in a domesticated species, such as chickens or Japanese quail; these species have unnaturally high egg-laying rates and toxicological and reproductive sensitivities that are very different from those of wild bird species. Comparing toxic threshold effects on reproductive endpoints for these species with reproductive endpoints for non-domesticated species is problematic because of differences in reproductive physiology.

The most conservative thresholds available from the published toxicological studies (i.e., the lowest LOAEL and highest bounded NOAEL[2]) that met the criteria presented above were selected as the TRVs, as presented in Table 5-7. Body weight-adjusted TRVs specific to lesser scaup were derived from the literature-based TRVs using the following equation based on Sample and Arenal (1999):

$$\mathbf{TRV_W = TRV_L \times \left({BW_S}/{BW_R}\right)^{(1-1.2)}} \qquad \textbf{Equation 5-4}$$

Where:

TRV_W	=	weight-adjusted TRV (mg/kg bw/day)
TRV_L	=	literature-based TRV (mg/kg bw/day)
BW_S	=	body weight of toxicity study receptor (kg)
BW_R	=	body weight of selected ecological receptor (kg)

These body weight-adjusted TRVs are presented in Table 5-7.

[2] The highest NOAEL below the selected LOAEL based on the same study or same endpoint as the selected LOAEL was selected as the NOAEL.

Table 5-6. Summary of bird TRVs based on comprehensive literature review

Constituent	NOAEL					LOAEL				
	TRV (mg/kg bw/day)	Species	BW (kg)	Effect	Source	TRV (mg/kg bw/day)	Species	BW (kg)	Effect	Source
Arsenic	10	mallard	1.082	egg laying; egg weight, production, and shell thinning; offspring body weight	Stanley et al. (1994)	40	mallard	1.082	egg laying; egg weight, production, and shell thinning; offspring body weight	Stanley et al. (1994)
Cadmium	1.5	mallard (young females)	0.8825	body weight	Cain et al. (1983)	4.0	Japanese quail (chicks)	0.093	male body weight	Richardson et al. (1974)
Chromium	10.5[a]	chicken (chicks)	0.254	body weight, adult mortality	Chung et al. (1985)	105	chicken (chicks)	0.254	body weight, adult mortality	Chung et al. (1985)
Cobalt	2.31[a]	chicken (chicks)	0.1462	body weight	Diaz et al. (1994)	23.1	chicken (chicks)	0.1462	body weight	Diaz et al. (1994)
Copper	16	chicken (chicks)	0.534	growth	Smith (1969)	19	chicken (chicks)	0.591	growth	Jensen and Maurice (1978)
Lead	5.5	Japanese quail (chicks)	0.0715	body weight	Morgan et al. (1975)	28	Japanese quail (chicks)	0.0715	body weight	Morgan et al. (1975)
Mercury	0.050	mallard	1.082	hatchability, egg production, and offspring survival	Heinz (1974)	0.064	mallard	1.0	egg and young production, eggshell thinning	Heinz (1979)
Molybdenum	3.0[a]	chicken	1.71	embryonic viability	Lepore and Miller (1965)	30	chicken	1.71	embryonic viability	Lepore and Miller (1965)
Nickel	17	chicken (chicks)	0.467	body weight	Weber and Reid (1968)	33	chicken (chicks)	0.39	body weight	Weber and Reid (1968)
Vanadium	1.2	chicken (hens)	1.71	body weight	Ousterhout and Berg (1981)	2.3	chicken (hens)	1.71	body weight	Ousterhout and Berg (1981)
Zinc	82	chicken (chicks)	0.534	growth	Roberson and Schaible (1960)	124	chicken (chicks)	0.534	growth	Roberson and Schaible (1960)

Constituent	NOAEL					LOAEL				
	TRV (mg/kg bw/day)	Species	BW (kg)	Effect	Source	TRV (mg/kg bw/day)	Species	BW (kg)	Effect	Source
Total PCBs	0.49	screech owl	0.181	eggshell thickness, egg production, and hatching/fledging success	McLane and Hughes (1980)	1.4	ringed turtle dove	0.155	hatching success in second generation	Peakall et al. (1972); Peakall and Peakall (1973)

[a] NOAEL is the LOAEL divided by 10.

BW or bw – body weight
LOAEL – lowest-observed-adverse-effect level
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value

Table 5-7. Summary of body weight-adjusted bird TRVs based on comprehensive literature review

Constituent	NOAEL TRV[a] (mg/kg dw/day)	NOAEL TRV bw (kg)	Scaup Weight-adjusted NOAEL (mg/kg bw/day)[b]	LOAEL TRV[a] (mg/kg dw/day)	LOAEL TRV bw (kg)	Scaup Weight-adjusted LOAEL (mg/kg bw/day)[b]
Antimony	na	na	na	na	na	na
Arsenic	10	1.082	**9.4**	40	1.08	**38**
Beryllium	na	na	na	na	na	na
Cadmium	1.5	0.8825	**1.5**	4	0.093	**6.2**
Chromium	10.5	0.254	**13.3**	105	0.254	**133**
Cobalt	2.31	0.1462	**3.26**	23.1	0.1462	**32.6**
Copper	16	0.534	**17**	19	0.591	**20**
Lead	5.5	0.0715	**8.9**	28	0.0715	**46**
Mercury	0.050	1.082	**0.047**	0.064	1.0	**0.061**
Molybdenum	3.0	1.71	**2.6**	30	1.71	**26**
Nickel	17	0.467	**19**	33	0.39	**38**
Silver	na	na	na	na	na	**na**
Vanadium	1.2	1.71	**1.0**	2.3	1.71	**2.0**
Zinc	82	0.534	**89**	124	0.534	**135**
Total PCBs	0.49	0.181	**0.66**	1.4	0.16	**2.0**

Shaded cells represent TRVs used in risk calculations.

[a] NOAEL and LOAEL were TRVs based on Table 5-6.

[b] TRVs were adjusted for lesser scaup based on a body weight of 0.815 kg (see Table 5-3).

bw – body weight
dw – dry weight
LOAEL – lowest observed adverse effect level
na – not available
NOAEL – no observed adverse effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value

In addition, EPA Region 9 Biological Technical Assistance Group (BTAG) guidance TRVs (EPA 2009), developed using a consensus-based process, were evaluated (Table 5-8). Like screening values, the BTAG TRVs are conservative. High and low TRVs correspond to LOAEL and NOAEL TRVs, respectively; the low TRV (NOAEL) represents the level at which adverse effects are not likely to occur, and the high TRV (LOAEL) represents the lowest concentration of potential adverse effects (Battelle et al. 2005). Body weight-adjusted TRVs specific to lesser scaup were derived from BTAG TRVs using Equation 5-4.

Table 5-8. Summary of EPA Region 9 BTAG bird TRVs

Constituent	NOAEL TRV[a] (mg/kg dw/day)	NOAEL TRV (bw kg)	Scaup Weight-adjusted NOAEL (mg/kg bw/day)[b]	LOAEL TRV[a] (mg/kg dw/day)	LOAEL TRV (bw kg)	Scaup Weight-adjusted LOAEL (mg/kg bw/day)[b]
Antimony	na[c]	na[c]	**na[c]**	na[c]	na[c]	**na[c]**
Arsenic	5.5	1.17	**5.1**	22	1.17	**20**
Beryllium	na[c]	na[c]	**na[c]**	na[c]	na[c]	**na[c]**
Cadmium	0.7[a]	0.51	**0.77**	10.4	0.084	**16.4**
Chromium	na[c]	na[c]	na[c]	na[c]	na[c]	**na[c]**
Cobalt	na[c]	na[c]	na[c]	na[c]	na[c]	**na[c]**
Copper	2.3	0.639	**2.4**	52.3	0.409	**60.0**
Lead	1.63[d]	1.81	**1.39**	8.75	0.80	**8.78**
Mercury	0.039	1.0	**0.037**	0.18	1	**0.17**
Molybdenum	na[c]	na[c]	na[c]	na[c]	na[c]	na[c]
Nickel	1.38	0.614	**1.46**	56.3	0.58	**60.3**
Silver	na[c]	na[c]	na[c]	na[c]	na[c]	**na[c]**
Vanadium	na[c]	na[c]	na[c]	na[c]	na[c]	**na[c]**
Zinc	17.2	0.955	**16.7**	172	0.955	**167**
Total PCBs	0.09	0.80	**0.0903**	1.27	1.72	**1.09**

Shaded cells represent TRVs used in risk calculations.

a NOAEL and LOAEL TRVs were based on low and high TRVs, respectively, reported by EPA Region 9 BTAG (EPA 2009).

b TRVs were adjusted for lesser scaup based on a body weight of 0.815 kg (see Table 5-3).

c No TRVs were available from EPA Region 9 BTAG (EPA 2009).

d NOAEL TRV was based on EPA Eco-SSL (EPA 2003). See text following this table for additional details.

bw – body weight
BTAG – Biological Technical Assistance Group
dw – dry weight
Eco-SSL – ecological soil screening level
EPA – US Environmental Protection Agency
LOAEL – lowest observed adverse effect level
na – not available
NOAEL – no observed adverse effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value

As discussed by Battelle et al. (2005), the BTAG NOAEL TRV for lead (0.014 mg/kg bw/day) is associated with high uncertainty; this TRV results in risk even under ambient (background) exposure, and it is much lower than widely accepted TRVs, such as those from Oak Ridge National Laboratory (Sample et al. 1996) or EPA ecological soil screening levels (Eco-SSLs) (EPA 2003). Consequently, the NOAEL based on the EPA Eco-SSL (1.63 mg/kg bw/day) (EPA 2005b) was used instead of the BTAG NOAEL to evaluate the potential for risk.

No BTAG TRVs were available for seven metals: antimony, beryllium, chromium, cobalt, molybdenum, silver, and vanadium.

6 Wildlife Risk Characterization

Dietary doses for lesser scaup were estimated using Equation 5-1 and exposure assumptions presented in Section 5.2. For risk characterization, dietary doses were then compared to the TRVs presented in Section 5.3 to derive a hazard quotient (HQ) using the following equation:

$$HQ = \frac{Dose}{TRV} \qquad \textbf{Equation 6-1}$$

Where:

HQ	=	hazard quotient (unitless)
Dose	=	calculated exposure dose (mg/kg bw/day)
TRV	=	toxicity reference value (mg/kg bw/day)

6.1 HQ Results

HQs based on literature-based TRVs and BTAG TRVs are presented in Tables 6-1 and 6-2, respectively. Using an SUF of 0.003, NOAEL and LOAEL HQs are all less than 1.0 for all constituents evaluated. Using an SUF of 0.03, HQs are less 1.0 based on literature-based NOAELs and LOAELs and on BTAG NOAELs and LOAELs.

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Table 6-1. Dietary HQs for lesser scaup using literature-based TRVs

Constituents	C_{sed} (mg/kg dw)	Invert BAF	C_{tissue} (mg/kg dw)	Dose (mg/kg bw/day)[a]	TRV (mg/kg bw/day)		SUF = 0.03		SUF = 0.003	
					NOAEL	LOAEL	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Antimony	2.52	0.17	0.428	0.00127	na	na	na	na	na	na
Arsenic	28.5	2.0	57.0	0.135	9.4	38	0.014	0.0036	0.0014	0.00036
Beryllium	0.71	1.0	0.710	0.00172	na	na	na	na	na	na
Cadmium	2.95	1.1	3.25	0.00784	1.5	6.2	0.0053	0.0013	0.00053	0.00013
Chromium	175	0.056	9.80	0.0418	13.3	133	0.0032	0.00032	0.00032	0.000032
Cobalt	24.8	0.13	3.22	0.0102	3.26	32.6	0.0031	0.00031	0.00031	0.000031
Copper	1,069	0.22	235	0.661	17	20	0.038	0.033	0.0038	0.0033
Lead	413	0.12	49.6	0.160	8.9	46	0.018	0.0035	0.0018	0.00035
Mercury	1.74	0.53	0.922	0.00233	0.047	0.061	0.049	0.038	0.0049	0.0038
Molybdenum	10.4	3.0	31.2	0.0734	2.6	26	0.028	0.0028	0.0028	0.00028
Nickel	277	0.078	21.6	0.0802	19	38	0.0042	0.0021	0.00042	0.00021
Silver	1.5	0.93	1.40	0.0034	na	na	na	na	na	na
Vanadium	75.6	0.057	4.31	0.0182	1.0	2.0	0.018	0.0092	0.0018	0.00092
Zinc	1,697	0.79	1341	3.29	89	135	0.037	0.024	0.0037	0.0024
Total PCBs	1.03	2.0	2.06	0.00489	0.66	2.0	0.0074	0.0025	0.00074	0.00025

Note: All HQs are < 1.0.

[a] Based on a SUF of 0.03.

BAF – biota accumulation factor
bw – body weight
dw – dry weight
HQ – hazard quotient
LOAEL – lowest observed adverse effect level
na – not available
NOAEL – no observed adverse effect level
PCB – polychlorinated biphenyl
SUF – site use factor
TRV – toxicity reference value

Table 6-2. Dietary HQs for lesser scaup based on BTAG TRVs

Constituents	C_{sed} (mg/kg dw)	Invert BAF	C_{tissue} (mg/kg dw)	Dose (mg/kg bw/day)[a]	TRV (mg/kg bw/day)		SUF = 0.03		SUF = 0.003	
					NOAEL	LOAEL	NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Antimony	2.52	0.17	0.428	0.00127	na	na	na	na	na	na
Arsenic	28.5	2.0	57.0	0.135	5.1	20	0.026	0.0066	0.0026	0.00066
Beryllium	0.71	1.0	0.710	0.00172	na	na	na	na	na	na
Cadmium	2.95	1.1	3.25	0.00784	0.77	16.4	0.010	0.00048	0.0010	0.000048
Chromium	175	0.056	9.80	0.0418	na	na	na	na	na	na
Cobalt	24.8	0.13	3.22	0.0102	na	na	na	na	na	na
Copper	1,069	0.22	235	0.661	2.4	60.0	0.27	0.011	0.027	0.0011
Lead	413	0.12	49.6	0.160	1.39	8.78	0.12	0.018	0.012	0.0018
Mercury	1.74	0.53	0.922	0.00233	0.037	0.17	0.062	0.013	0.0062	0.0013
Molybdenum	10.4	3.0	31.2	0.0734	na	na	na	na	na	na
Nickel	277	0.078	21.6	0.0802	1.46	60.3	0.055	0.0013	0.0055	0.00013
Silver	1.5	0.93	1.40	0.0034	na	na	na	na	na	na
Vanadium	75.6	0.057	4.31	0.0182	na	na	na	na	na	na
Zinc	1,697	0.79	1,341	3.29	16.7	167	0.20	0.020	0.020	0.0020
Total PCBs	1.03	2.0	2.06	0.00489	0.0903	1.09	0.054	0.0045	0.0054	0.00045

Note: All HQs are < 1.0.

[a] Based on a SUF of 0.03.

BAF – biota accumulation factor
BTAG – Biological Technical Assistance Group
bw – body weight
dw – dry weight
HQ – hazard quotient
LOAEL – lowest observed adverse effect level
na – not available
NOAEL – no observed adverse effect level
PCB – polychlorinated biphenyl
SUF – site use factor
TRV – toxicity reference value

6.2 UNCERTAINTY

It is important to identify the uncertainties associated with the exposure and effects assumptions used to characterize risks (EPA 1997, 1998; California DTSC 1996). The following key uncertainties were identified:

- The greatest uncertainty associated with this risk evaluation is the use of BAFs to model prey tissue in the absence of empirical data. Regional data (from Hunters Point Shipyard) were used to establish BAFs, but it is unknown whether these BAFs over- or under-predict concentrations in potential benthic invertebrate tissue that may be prey for birds in the lower riprap/subtidal unit. Tissue concentrations vary based on site-specific parameters, including bioavailability and lipid content of organisms present in the sediment. Typically, non-site-specific BAFs over-predict actual prey tissue concentrations due to inherent conservative assumptions in the model.
- The selected SUFs are associated with some level of uncertainty; however, the range of SUFs selected (0.003 to 0.03) represents a conservative estimate of the lesser scaup's expected use of the Project Area. An SUF of 0.03 is expected to overpredict the potential for risk in the Project Area. Furthermore, using literature-based TRVs, the SUF can be as high as 0.6 (i.e., based on the highly unrealistic assumption that diving birds would use the Project Area 60% of the time when they forage) to have NOAEL and LOAEL HQs < 1. Thus, given the conservative assumptions throughout the risk estimation process, there is little likelihood of unacceptable ecological risk.
- There is uncertainty associated with the TRVs selected for the evaluation of risk. It is unknown whether the lesser scaup is more or less sensitive to the contaminants being evaluated than the species tested in the selected TRVs studies; however, the selected TRVs do represent the most sensitive species tested in the available toxicological literature. BTAG TRVs include NOAELs and LOAELs based on endpoints other than survival, growth, and reproduction, which may overpredict the potential for adverse effects on ecological populations.
- The exposure parameters assumed for lesser scaup in the dietary model were considered to be associated with relatively low uncertainty, since body weights and ingestion rates specific to the species were available from the general literature.
- This assessment assumed 100% bioavailability, a highly conservative assumption given that actual bioavailability will be much less under environmental conditions.

7 ERA Conclusions and Recommendations

Based on the limited habitat in the Project Area relative to nearby habitat, its very small size, its industrial location, and the lack of unacceptable risk to the ecological community and populations based on a conservative SUF, it is recommended that the sediments in the Project Area remain in place. This recommendation is based on risk estimates following methods used at similar sites in the vicinity and EPA guidance.

The benthic community in the upper few centimeters is typical of what would be expected in an industrial shipping channel. Based on site-specific chemistry data, risk analyses of nearby benthic toxicity and community, and the lack of causative toxicity of constituents at concentrations found at the site, there exists low probability of unacceptable risk to the benthic community from COCs at the site.

The wildlife populations, as predicted by the risk estimation of the maximally exposed representative species, have probable risk estimates well below an HQ of 1.0 (the benchmark for further evaluation). The risk estimates are below levels that would result in unacceptable risk using an appropriately conservative SUF and TRVs. The potential risk to aquatic birds that may utilize the Project Area (specifically, the lower riprap/subtidal unit) is considered negligible based on the risk characterization results. Exposure is limited, and even given conservative assumptions in the risk assessment (i.e., no-effect and low-effect thresholds, SUFs, likelihood of feeding preference, and bioavailability of constituents), there is little likelihood for unacceptable risk in the lower riprap/subtidal unit.

8 Potential for Future Risk from Disturbance of Sediments

As provided in Paragraph 19 of the Consent Decree, Sims "shall also consider the potential environmental impacts associated with disturbance of the sediment, and Sims may propose to leave the sediments and agglomerated scrap metal in place if supported by the results of an ecological risk assessment." This section discusses the potential impacts associated with disturbance of the sediment if remedial action were to occur.

As presented in this document, an ecological evaluation of the potential for unacceptable risk was completed for the appropriate ecological exposure areas of the Project Area (i.e., the lower riprap/subtidal unit) using site-specific data and exposure assumptions. The evaluation was based on methodologies similar to those used in regional sediment risk assessment and remedial evaluation plans for nearby locations.

The ERA evaluated the upper riprap unit and determined that there was an insignificant (i.e., *de minimis*) pathway to ecological receptors. The area is covered in boulders, and while there are limited pockets of sediment, they are not sufficient from a habitat perspective for ecological receptor exposure. Furthermore, this area is designated as industrial (ESA 2017).This ERA concluded that no unacceptable risk is expected in the lower riprap/subtidal unit.

The ERA evaluated risk due to exposure to sediments in the BAZ, which was defined as the top 0.5 ft of sediment. Concentrations of COCs in sediment below that depth were not considered. This is a reasonable approach, given that the Project Area is in a depositional environment. The navigation channel in Redwood Creek has required dredging every two years since 1965 (HydroPlan 2015). The average annual volume of sediment deposited in the Redwood Creek Harbor Channel is approximately five million cubic feet. Given an area of approximately 8.8 million square feet, the average sedimentation rate is more than 6 in. per year (HydroPlan 2015). Furthermore, the Project Area is tightly constrained by piles supporting the wharf and other overwater structures; these structures would be expected to decrease tidal current velocities, creating a low-energy environment conducive to sediment deposition. No vessel traffic occurs shoreward of the wharf, limiting the potential for sediment erosion from vessel propwash scour. The vertical distribution of COCs in Project Area sediment (Terraphase 2018) is consistent with net sediment accretion in the area. Therefore, it is reasonable to assume that, unless disturbed by human activity, the sediments will remain in place in both the upper riprap unit and the lower riprap/subtidal unit.

The potential for unacceptable risk from sediment disturbance has been well documented over the last two decades of sediment remediation and risk analyses. EPA recognizes the difficulty of dealing with sediment remediation projects and has issued two policy documents on managing sediments (EPA 2002b, 2005a). As discussed by Nadeau (2016), the focus on mass removal of sediments under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has disregarded the policies of "risk reduction." The resuspension and release of contaminants has resulted in an increased potential for risk, as demonstrated in Commencement Bay and the Lower Duwamish Waterway, both major sediment remediation sites in the state of Washington. In addition, CSTAG has recommended that sites such as New York's Gowanus Canal be evaluated due to the "expected limited effectiveness of dredging."

The resuspension of sediment during dredging is also a significant source of contaminants to the water column. According to Bridges et al. (2008), resuspended sediment can remain in the water column for hours, be transported via currents into the surrounding environment, and introduce contaminants into the dissolved phase. In addition to leaving behind "undisturbed residuals," the dredging process creates "generated residuals." (Bridges et al. 2008).

Furthermore, the upper riprap unit is already covered by large rocks, which limit the exposure of potential receptors to incidental ingestion. Because the exposure pathway to the upper riprap unit is *de minimis*, the ecological risk posed by the upper riprap is negligible. Any destruction or disturbance of the riprap bank could, in fact, increase the likelihood of future ecological risk, as has occurred at other sediment sites around the United States (Nadeau 2016). If the sediments are disturbed, constituents now sequestered in place could become entrained in the water column, thereby becoming more bioavailable to benthic invertebrates, fish, and wildlife. As noted in recent EPA and Contaminated Sediments Technical Advisory Group (CSTAG) briefings and guidance (EPA 2002b, 2005a), sometimes it is better for the environment to leave constituents in sediments in place, particularly if the current risk is low to moderate, rather than potentially increasing risk by disturbance.

Ultimately, it is recommended to leave the Project Area sediments in place. As EPA policy and examples discussed herein demonstrate, disturbance will increase this area's potential to contribute more elevated concentrations of constituents to the aquatic environment, where there is the potential for the ecological exposure of receptors. These constituents would be entrained into the water column and become more bioavailable than they are currently, potentially contributing to future risk. Therefore, based on the a) insignificant ecological pathway in the upper riprap unit, b) lack of unacceptable risk, even using conservative assumptions, in the lower riprap/ subtidal unit, and c) area of accretion of sedimentation, it is recommended that the sediments remain in place and not be disturbed.

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Appendix A. Benthic Community Potential Risk Evaluation

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Acronyms

BAZ	biologically active zone
COC	constituent of concern
DDT	dichlorodiphenyltrichloroethane
dw	dry weight
ERM	effects range – median
ERMq	effects range – median quotient
ERA	ecological risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbons
LOEC	lowest-observed-effect concentration
LPAH	low-molecular-weight polycyclic aromatic hydrocarbons
NOEC	no-observed-effect concentration
PCB	polychlorinated biphenyl
SCCWRP	Southern California Coastal Water Research Program
SETAC	Society of Environmental Toxicology and Chemistry
TBT	tributyltin

1 Introduction

The Project Area is part of an industrial shipping channel and active industrial use area. Therefore, the benthic community in the Project Area is subject to the associated pressures, making it questionable whether a management goal for benthic community protection is appropriate for this site. Regardless, for completeness, a benthic community evaluation was conducted as part of the ecological risk assessment (ERA). As for the wildlife assessment, ERAs completed for sites in the vicinity of the Project Area were reviewed as part of a line-of-evidence evaluation to determine if the benthic community is being adversely affected by the metals and polychlorinated biphenyls (PCBs), collectively refered to as constituents of concern (COCs), detected in Project Area sediment within a relevant exposure area.

The probability of risk to the benthic community has been indirectly assessed using the data available for COC concentrations in the upper 0 to 15 cm of sediment. This depth reasonably represents the biologically active zone (BAZ) for the majority of the benthic species in the mesohaline environment of San Francisco Bay, as discussed in Section 3.1 of the main document.

As described in the main document, for the purposes of the ERA, the Project Area was divided into two exposure evaluation units: the upper riprap unit and the lower riprap/subtidal unit. The upper riprap unit consituents identified in pockets of sediment in between the rock boulders were not evaluated quantitatively, since this sediment represents an insignificant *de minimis* pathway to ecological receptors (see main text). Surface sediment concentrations within the BAZ (0 to -15 cm) in the lower riprap/subtidal unit were evaluated qualitatively through a comparison to effects range – median (ERM) screening values in Section 2 of this appendix. Benthic community and toxicitiy data from nearby mesohaline environment sites, including the Hunters Point Shipyard Parcel F site, were also used to evaluate the probability that the benthic community in the Project Area is at risk due to exposure to sediment chemicals, as detailed in Section 3 of this appendix.

2 Sediment Chemistry

Sediment constituent concentrations (Terraphase 2018) from a depth of 0 to 15 cm in the ecological exposure area (i.e., lower riprap and subtidal areas) exceed ERM values (Table A2-1). However, comparison to ERM values should not be used to predict effects in risk assessments (Long and Morgan 1990; Long et al. 1995; MacDonald et al. 1996). Regional data support the lack of a relationship between ERM exceedances and adverse effects on the benthic invertebrate community. As described in Section 3, the regional sediment toxicity data and regional benthic community data suggest that there is minimal risk to be expected for benthic populations within the Project Area.

Table A2-1. Comparison of lower riprap/subtidal unit surface sediment concentrations to ERM values

Area	Location	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Mercury mg/kg	Nickel mg/kg	Silver mg/kg	Zinc mg/kg	Total PCBs µg/kg
ERM		70	9.6	370	270	218	0.71	51.6	3.7	410	180
Count of samples > ERM (% samples)		1 (2%)	0 (0%)	3 (6%)	16 (33%)	8 (17%)	13 (27%)	48 (100%)	2 (4%)	23 (48%)	34 (71%)
Lower riprap	W3-10	32	4.02	120	**365**	171	**1.7**	**705**	1.38	**1,770**	**304**
Lower riprap	W3-11	**79.5**	5.94	**461**	**2,320**	**379**	**1.27**	**222**	**6**	**4,740**	**1,670**
Lower riprap	W3-12	56.2	2.52	261	**2,230**	**1,120**	0.448	**218**	1.84	**3,120**	**1,670**
Lower riprap	W3-13	19.1	7.49	228	**1,640**	**469**	0.641	**688**	1.28	**4,910**	**1,940**
Lower riprap	W3-19	12.8	1.56	101	238	106	0.526	**108**	0.403 J	**541**	**1,290**
Lower riprap	W3-20	20.5	3.51	122	185	152	**0.798**	**130**	0.402 J	**955**	**1,050**
Lower riprap	W3-21	11.7	1.55	107	132	76.9	**1.45**	**124**	0.522 J	**572**	**540**
Lower riprap	W3-26	23.4	0.555 J	104	212	77.2	0.323	**122**	1.24	**913**	153
Lower riprap	W3-27	68.7	3.33	**488**	**3,970**	**614**	0.562	**371**	2.54	**3,610**	**2,010**
Lower riprap	W3-28	46.7	5.38	161	**623**	**447**	0.672	**180**	1.5	**2,670**	**1,070**
Lower riprap	W3-29	16.8	1.33	114	**579**	147	0.507	**98.7**	0.729	**919**	**1,500**
Lower riprap	W3-30	12.8	0.644 J	95.7	77.7	51.1	0.338	**101**	0.431 J	342	**242**
Lower riprap	W3-58	9.23	1.65	92.1	68.2	46.2	0.486	**102**	0.593 J	232	**240**

Table A2-1. Comparison of lower riprap/subtidal unit surface sediment concentrations to ERM values

Area	Location	Arsenic mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Mercury mg/kg	Nickel mg/kg	Silver mg/kg	Zinc mg/kg	Total PCBs µg/kg
Subtidal	W3-01	12.1	1.45 U	89.7	66.6	41.7	0.34	**103**	0.796	208	123
	W3-02	17.5	1.46 U	101	106	60.8	**0.752**	**114**	1.28	425	**329**
	W3-03	12.7	1.46 U	89.7	65.5	41.5	0.389	**98.7**	0.752	202	119
	W3-04	17.9	1.74 U	93.5	76	47.5	0.482	**104**	1.01	247	135
	W3-05	20.8	0.516 J	116	**458**	216	0.4	**138**	1.45	**768**	**381**
	W3-06	13.6	1.65 U	98.5	93.3	49.4	0.347	**109**	0.782 J	273	154
	W3-07	47.6	5	**780**	**2,280**	**312**	**1.02**	**931**	1.16	**3,340**	**2,510**
	W3-08	31.4	2.93	128	**360**	217	**1.37**	**352**	0.894	**1,940**	**2,010**
	W3-09	19.9	2.29	126	**416**	**277**	**1.4**	**161**	0.402 J	**1,060**	**369**
	W3-32	10.4	0.804 J	106	73.8	96.9	0.375	**103**	0.288 J	459	116
	W3-33	9.58	0.504 J	97.9	68.2	36.8	0.353	**99.3**	0.262 J	191	102
	W3-34	6.78	0.593 J	82.4	**534**	41.2	0.181 U	**88.5**	0.23 J	228	**372**
	W3-35	9.02	0.58 J	92.2	56.7	34.7	0.374	**93.3**	0.417 J	163	72
	W3-36	9.7	0.974 J	109	80.7	53.4	0.531	**142**	0.363 J	266	**184**
	W3-37	9.57	0.692 J	99.7	76.2	44.4	0.529	**112**	0.356 J	245	**194**
	W3-38	6.89	0.872 J	110	68.5	52.2	**0.855**	**118**	0.262 J	243	**265**
	W3-39	7.68	0.502 J	103	67.8	40.4	0.0613 J	**107**	0.455 J	200	107
	W3-40	7.93	0.823 J	106	77.8	154	0.616	**110**	0.258 J	250	**392**
	W3-41	15.8	5.49	149	**458**	**2,240**	0.434	**160**	**3.8**	**1,700 B**	**990**
	W3-42	8.35	1.07 J	104	113	54.2	0.309	**106**	0.666 U	334 B	**281**
	W3-43	20.2	2.59	159	**511**	114	0.443 B	**118**	0.309 J	**780**	**710**
	W3-44	17.3	0.741 J	95	117	63.8	0.549 B	**96.3**	0.37 J	390	**460**
	W3-45	15.2	0.531 J	108	89.1	53.6	**0.876 B**	**107**	0.439 J	275	173
	W3-46	7.81	0.739 J	87.7	73.2	40.2	0.688	**96.3**	0.218 J	232	149
	W3-47	21.4	1.46 U	155	**1,710**	63.3	0.456 B	**131**	0.728 U	**572**	**356**
	W3-48	16.5	5.12	169	**3,120**	186	**10.5**	**182**	0.779	**2,180**	**2,050**
	W3-49	12.1	2.38	115	217	103	0.484	**120**	1.16	**658 B**	**560**
	W3-50	11.7	1.22	115	237	103	0.371	**121**	0.476 J	**591**	**800**
	W3-51	7.18	0.701 J	79.6	58.6	33.9	0.379	**91.6**	0.714 U	173	107
	W3-52	8.93	0.734 J	90.5	68	44.5	0.252	**97.2**	0.269 J	227	174
	W3-53	8.54	0.796 J	93.4	61.4	37	0.371	**94.8**	0.507 J	180	**190**
	W3-54	7.35	0.676 J	78.9	54.5	32.6	0.16 J	**79.8**	0.798 U	166	**190**
	W3-55	7.79	1.55 J	87.6	55.2	54.4	0.334	**87.3**	0.437 J	172	61
	W3-56	9.66	1.76	92.7	68.6	62.8	0.421	**94.1**	0.553 J	216	**210**
	W3-57	8.34	1.47 J	103	61.6	43.5	**1.74**	**107**	0.3 J	183	**230**

Bold values are greater than the respective ERM concentration.

B – analyte present in an associated method blank
ERM – effects range – median
PCB – polychlorinated biphenyl
J – estimated concentratration
U – not detected at given concentration

3 Potential Risk to the Benthic Community

The potential risk to the Project Area benthic community is assessed in this section using multiple lines of evidence:

- An evaluation of benthic community and toxicitiy data from a nearby site's ERA (i.e., Hunters Point Shipyard Parcel F site) (Battelle et al. 2005)
- A comparison of infaunal community data metrics from the south bay of San Francisco Bay ERMs (SCCWRP 2010)
- An assessment of spiked sediment toxicity data (SETAC SEDAG and SCCWRP 2018)

3.1 Hunters Point Shipyard Parcel F Site Benthic Data

As noted in Section 3.1 of the main document, the feeding mode for most of the benthic species that inhabit the mesohaline environment of San Francisco Bay is consuming detritus and near-surface sediments, or filtering suspended particles in the near-bottom water column. Exposure to Project Area sediment is well represented by the two species used in the Hunter's Point Shipyard Parcel F site investigation (Battelle et al. 2005), which included acute sediment toxicity tests using the amphipod *Eohaustorius estuarius* and the urchin *Stronglyocentrotus purpuratus* larval tests. A larval test is used to evaluate the potential toxicity of dissolved concentrations and suspended particles. Project Area and Hunters Point Shipyard Parcel F site sediment concentration ranges overlap for several metals and total PCBs in sediment. However, zinc and lead concentrations in the lower riprap/subtidal unit surface sediment are higher than those found at the Hunters Point Shipyard Parcel F site (Table A3-1). Approximately 48 and 17% of lower riprap/subtidal unit surface sediment samples have zinc and lead concentrations greater than the ERM, respectively.

Table A3-1. Comparison of Hunters Point Shipyard Parcel F site and Project Area lower riprap/subtidal surface sediment concentrations

Chemical	Surface Sediment Concentration Range (mg/kg dw)		ERM (mg/kg)
	Hunters Point Shipyard Parcel F Site	Project Area Lower Riprap/Subtidal Unit	
Arsenic	5.18–18.2	6.78–**79.5**	70
Cadmium	0.184–0.845	0.5–7.49	9.6
Chromium	156–**464**	78.9–**780**	370
Copper	12–**1,050**	54.5–**3,970**	270
Lead	11 –**275**	32.6–**2,240**	218
Mercury	0.0808–7.47	0.0613 –**10.5**	0.71
Nickel	**59.6–250**	**79.8–931**	51.6

Table A3-1. Comparison of Hunters Point Shipyard Parcel F site and Project Area lower riprap/subtidal surface sediment concentrations

Chemical	Surface Sediment Concentration Range (mg/kg dw) Hunters Point Shipyard Parcel F Site	Surface Sediment Concentration Range (mg/kg dw) Project Area Lower Riprap/Subtidal Unit	ERM (mg/kg)
Silver	< 0.066–2.8	0.218–**6.0**	3.7
Zinc	47–322	163–**4,910**	410
Total PCBs	0.011–**5.186**	0.061–**2.510**	0.180

Sources: Hunters Point Shipyard Parcel F site data are from Battelle et al. (2005) and Redwood Creek Project Area data are from Terraphase (2018).

Bold concentrations are greater than the respective ERM value.

dw – dry weight

ERM – effects range median

PCB – polychlorinated biphenyl

Although some sediment concentrations in the Hunters Point Shipyard Parcel F site samples exceeded ERM values, the sediment toxicity test data showed only a limited toxicity response. Furthermore, Battelle et al. (2005) plotted the toxicity response data for the urchin (*S. purpuratus*) larval test against the sediment concentration data and found no dose-response relationship or relationship between actual toxicity response and predicted toxicity response based on exceedance of the respective ERM value. Amphipod (*E. estuaries*) data were also plotted against sediment concentration data (Figures A3-1 through A3-3). Similarly, no dose-response relationship or relationship between actual toxicity response and predicted toxicity response based on exceedance of the respective ERM value was found.

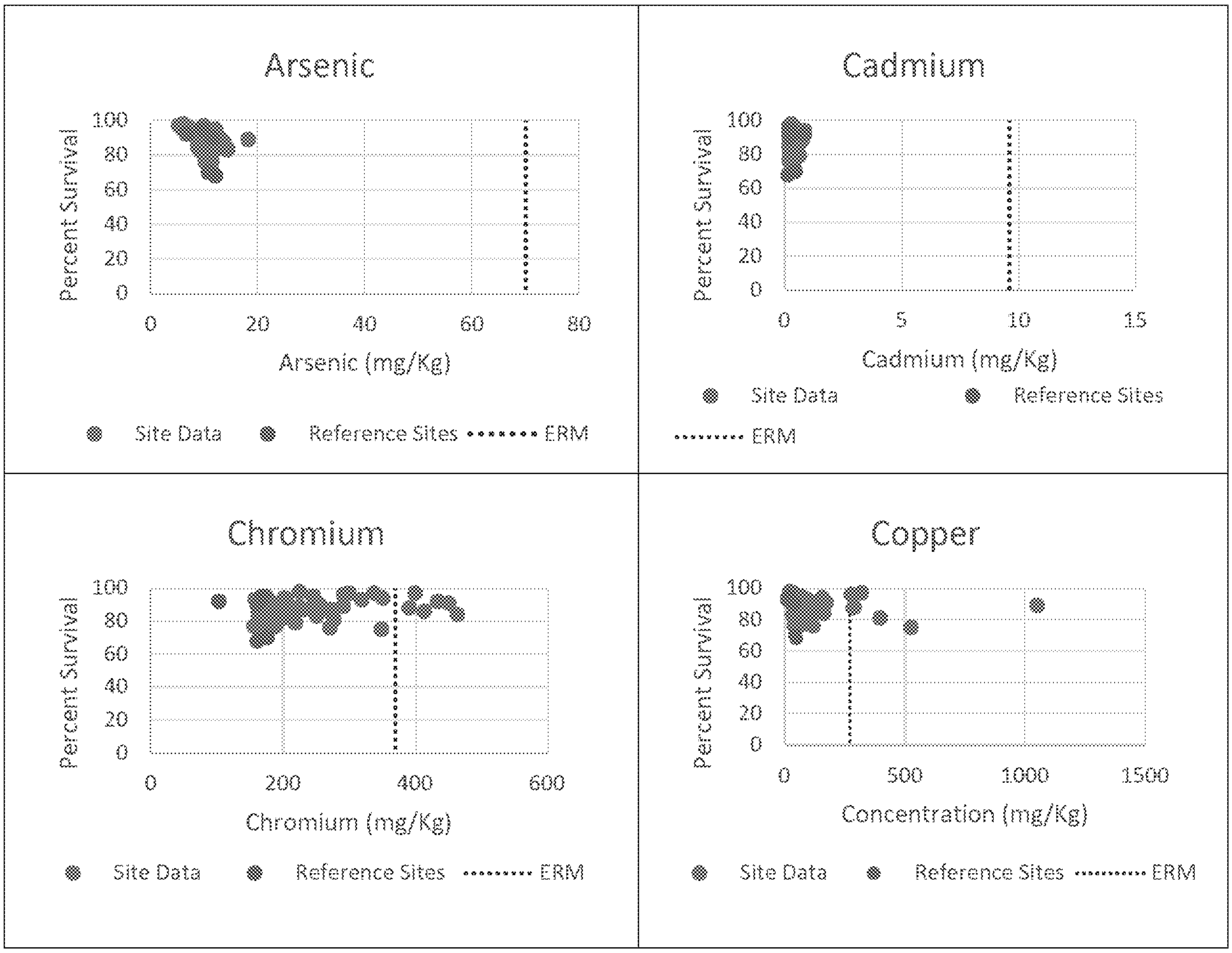

Figure A3-1. *Eohaustorius estuarius* percent survival plotted against Hunters Point Shipyard Parcel F site surface sediment arsenic, cadmium, chromium, and copper concentrations

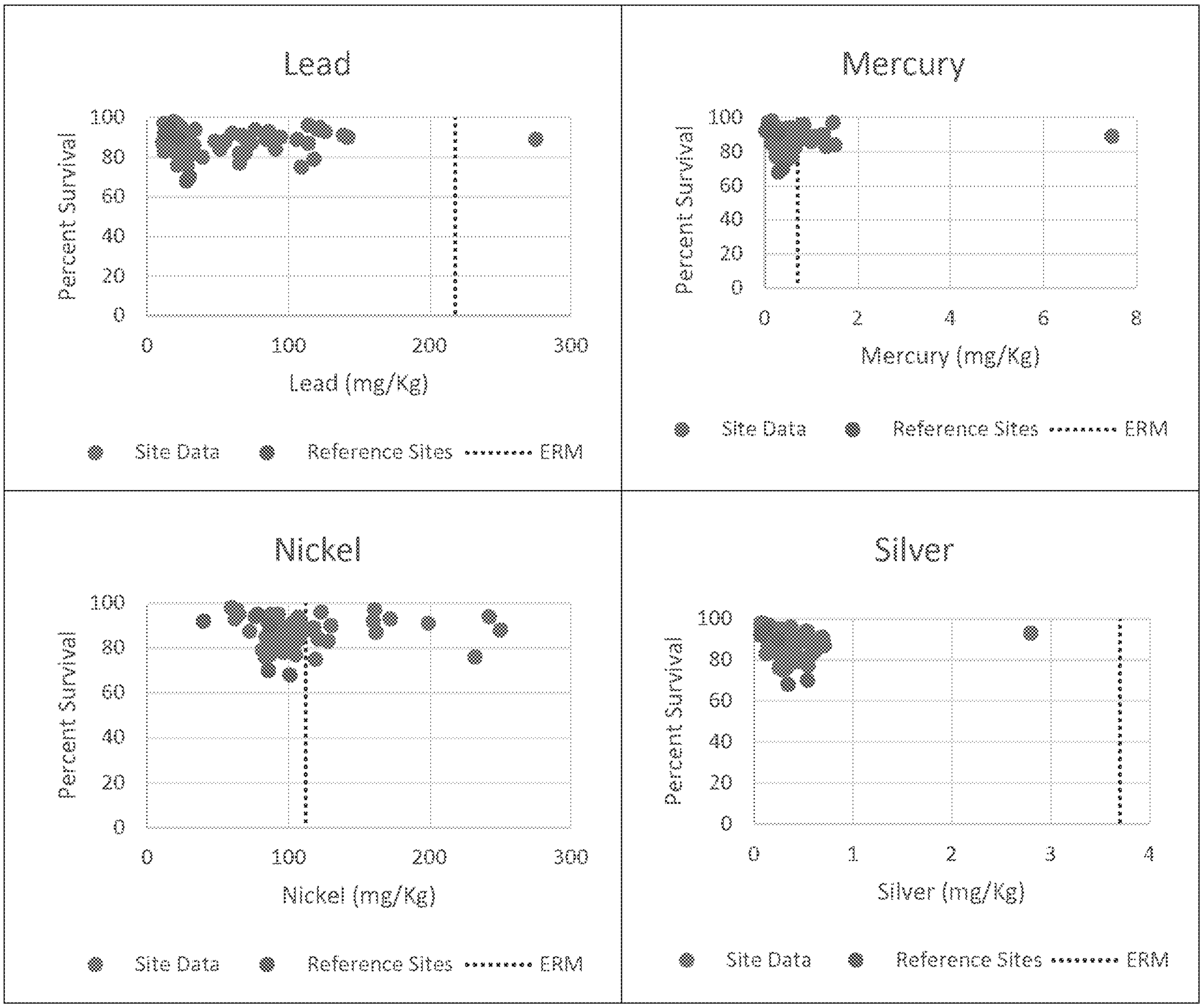

Figure A3-2. *Eohaustorius estuarius* percent survival plotted against Hunters Point Shipyard Parcel F site surface sediment lead, mercury, nickel, and silver concentrations

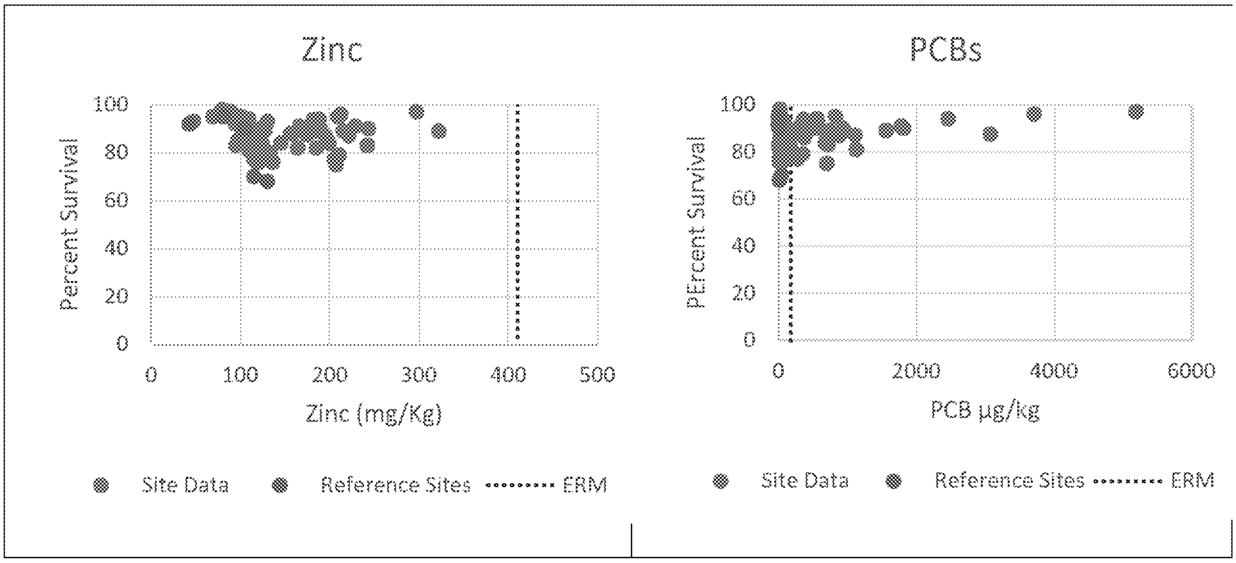

Figure A3-3. *Eohaustorius estuarius* percent survival plotted against Hunters Point Shipyard Parcel F site surface sediment zinc and PCB concentrations

In addition, no dose response for Hunters Point Shipyard Parcel F site data or reference site data was noted when the toxicity response was plotted with ERM quotient (ERMq) values (Figures A3-4 and A3-5). The ERMqs for the Hunters Point Shipyard Parcel F site included antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, selenium, zinc, total dichlorodiphenyltrichloroethanes (DDTs), dieldrin, endrin, total low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs), total high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs), alpha-chlordane, total PCBs, and tributyltin (TBT). As noted by Battelle et al. (2005), it is not unexpected for toxicity response to be low at locations where a high ERMq is driven by PCBs, because PCBs bioaccumulate but are not acutely toxic. However, toxicity at the Hunters Point Shipyard Parcel F site did not appear to be related to elevated sediment chemical concentrations, even at locations where metals rather than PCBs drove the ERMq (Battelle et al. 2005).

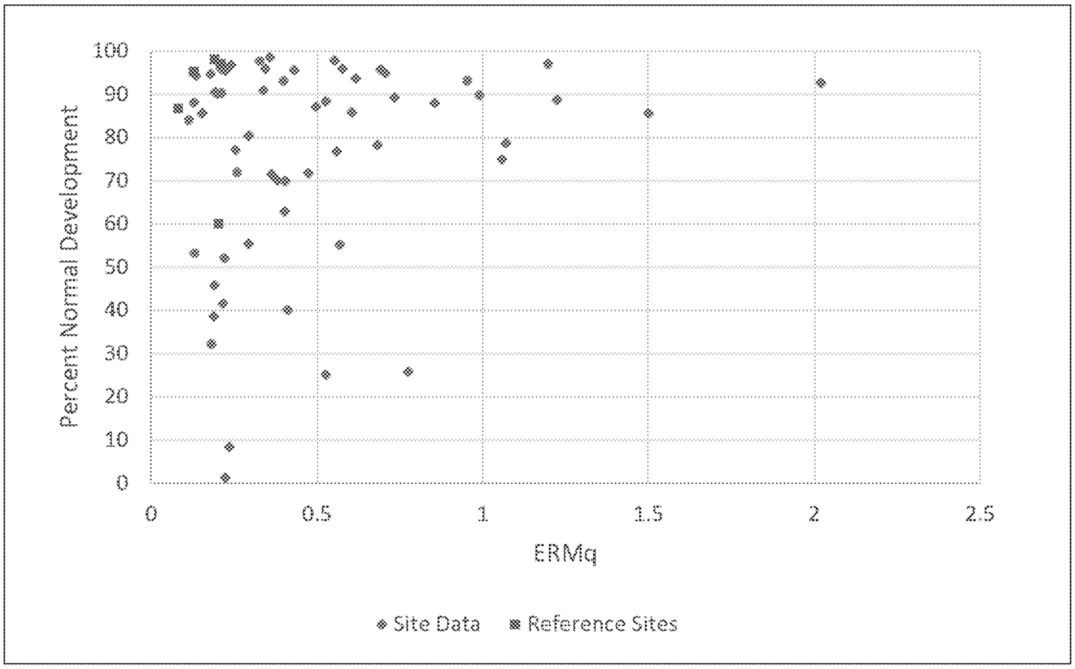

Figure A3-4. ***Stronglyocentrotus purpuratus*** **normal development data plotted with Hunters Point Shipyard Parcel F site ERM quotient surface sediment values**

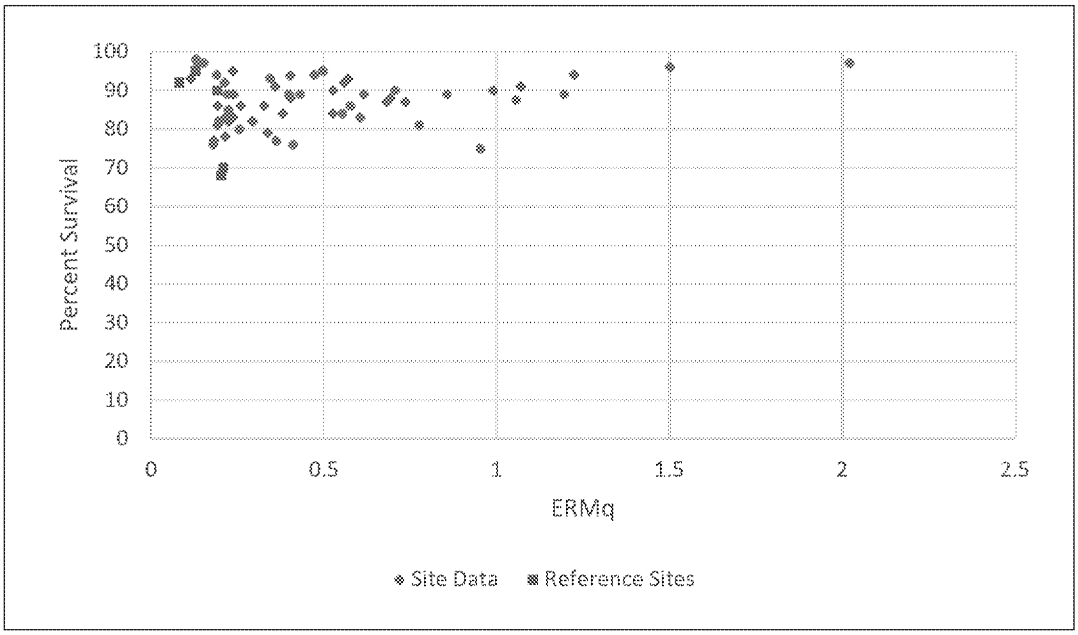

Figure A3-5. ***Eohaustorius estuaries*** **percent survival data plotted with Hunters Point Shipyard Parcel F site ERM quotient surface sediment values**

3.2 SOUTH BAY SAN FRANCISO BENTHIC DATA

The Hunters Point Shipyard Parcel F site toxicity data are in agreement with the benthic community data collected in San Francisco Bay that have been compared to ERMq values. Benthic species richness and *Ampelisca abdita* abundance data from the (SCCWRP) California sediment quality objectives database were plotted against ERMq values (for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) derived from co-located sediment samples within the mesohaline area of the south bay of San Francisco Bay (SCCWRP 2010). Sample locations are provided in Figure A3-6 and include one location in Redwood Creek. No concentration response to species richness or *A. abdita* abundance was found as ERMq values increased (Figures A3-7 and A3-8). This is not surprising, since Dr. Edward Long, the primary developer of the effects-range sediment quality value method, has noted in multiple publications that ERM values should only be used as a screening tool in risk assessments, not as a predictor of effects (Long and Morgan 1990; Long et al. 1995; MacDonald et al. 1996).

Lower riprap/subtidal unit surface sediment concentrations within the Project Area and Hunters Point Shipyard Parcel F site concentration ranges overlap for several metals (with the exception of zinc and lead) and total PCBs. The toxicity and community data from the Hunters Point Shipyard Parcel F site and community data from the mesohaline area of the south bay of San Francisco Bay collectively suggest that there is no risk to benthic populations within the Project Area. However, there is some uncertainty for zinc and lead, given the higher zinc and lead concentrations in the sediment in the lower riprap/subtidal unit of the Project Area when compared to the Hunters Point Shipyard Parcel F data.

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Figure A3-6. Benthic community and co-located chemistry data locations within the mesohaline area of the south bay of San Francisco Bay

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Prepared by mikey, 2/28/2018; W:\Projects\Sims Group\Data\GIS\Maps and Analyses\ERA\Fig A3-6_6751_Benthic community and colocated chemistry data locations.mxd

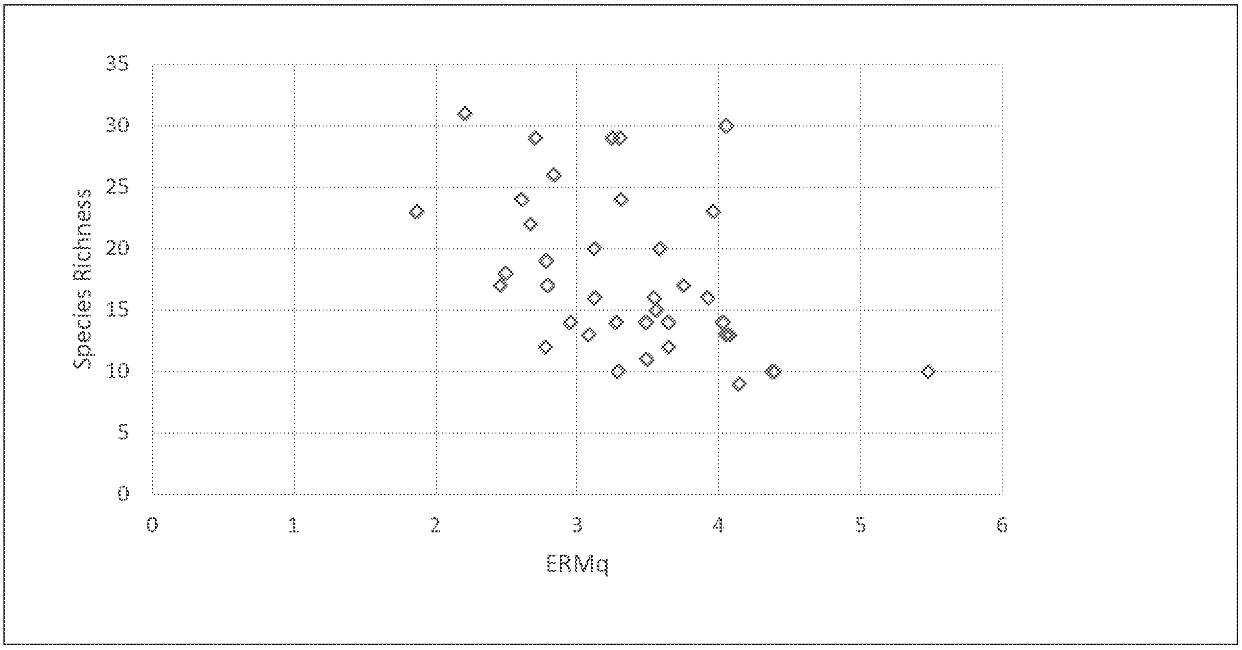

Figure A3-7. Species richness plotted against ERM quotient values of co-located sediment metal concentrations from samples collected in the south bay of San Francisco Bay

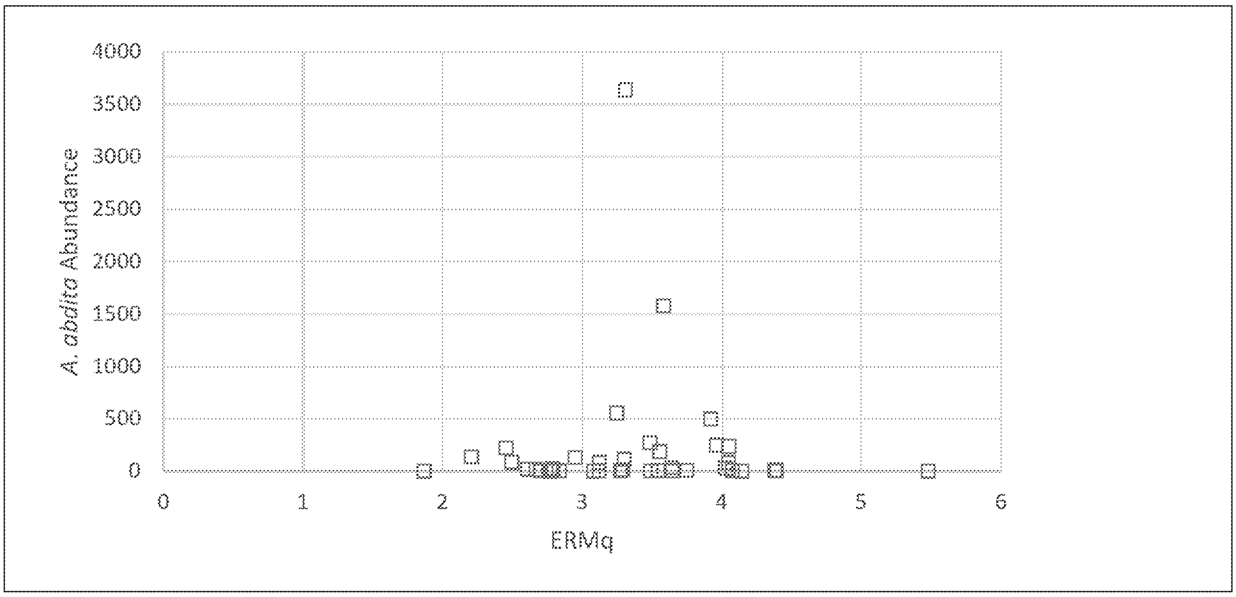

Figure A3-8. *Ampelisca abdita* abundance plotted against ERM quotient values of co-located sediment metal concentrations from samples collected in the south bay of San Francisco Bay

3.3 SPIKED SEDIMENT BENTHIC TOXICITY DATA

Zinc and lead concentrations found in the Project Area lower riprap/subtidal unit surface sediment were higher than those found at the Hunters Point Shipyard Parcel F site and exceeded the ERM screening values (Table A3-1). To address the potential risk to benthic organisms from zinc and lead concentrations in the range found in Project Area sediment, data from the SCCWRP and Society of Environmental Toxicology and Chemistry (SETAC) spiked sediment toxicity database (SETAC SEDAG and SCCWRP 2018) was reviewed. The database is a compilation of results from sediment toxicity tests in which benthic organisms (mostly amphipods) were tested using clean sediment that was spiked with a known chemical. The test results, therefore, are a direct measure of the cause and effect relationship for the tested chemical. A summary of the test data available in the database, reported as the no observable effect concentrations (NOECs) and lowest observable effect concentrations (LOECs), is presented in Table A3-2.

Table A3-2. Comparison of spiked sediment toxicity data and Project Area lower riprap/subtidal unit surface sediment concentrations

						Project Area Lower Riprap/Subtital Unit Concentration (mg/kg)			
						Subtidal		Lower Riprap	
Analyte	Taxa	Species	Endpoint	NOEC Concentration Range (mg/kg)	LOEC Concentration Range (mg/kg)	Min.	Max.	Min.	Max.
Zinc	amphipod	*Melita plumulosa*	survival	1,520–1,770	2,290	163	3,340	232	4,910
	bivalve	*Tellina deltoidalis*	survival	4,000	na				
Lead	amphipod	*Leptocheirus plumulosus*	survival	3,820–5,260	795–3,820	32.6	2,240	46.2	1,120
	amphipod	*Melita plumulosa*	survival	580–3,560	na				

LOEC – lowest-observed-effect concentration
na – not available
NOEC – no-observed-effect concentration

The results in Table A3-2 show that lower riprap/subtidal unit surface sediment zinc concentrations (163 to 3,340 mg/kg) overlap with the concentration ranges for NOECs (1,520 to 4,000 mg/kg) and LOECs (2,290 mg/kg). Similarly, the lower riprap/subtidal unit surface sediment concentration range for lead (32.6 to 2,240 mg/kg) is within the ranges for NOECs (580 to 5,260 mg/kg) and LOECs (795 to 3,820 mg/kg). It is important to note that the higher observed concentrations of zinc (232 to 4,910 mg/kg) are from the lower riprap areas. While these concentrations are above the LOEC and NOEC values reported in Table A3-2, the lower riprap areas provide little habitat for amphipods, polychaetes, and bivalves. Regional toxicity and community data, in conjunction with the spiked sediment toxicity data, suggest that there may be minimal risk to benthic populations within the Project Area.

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Appendix B. Avian Wildlife TRV References

1 Introduction

Table B1 presents the list of references consulted in the toxicity reference value (TRV) literature review. From this comprehensive review, TRVs were selected for use in the Redwood Creek ecological risk assessment (ERA).

Table B1. Summary of bird TRV references reviewed

Chemical	Sources reviewed
Arsenic	Camardese et al. (1990); USFWS (1964); Whitworth et al. (1991); Stanley et al. (1994)
Cadmium	Cain et al. (1983); DiGiulio and Scanlon (1984); Freeland and Cousins (1973); Leach et al. (1979); Pritzl et al. (1974); Richardson et al. (1974); White and Finley (1978a, b)
Chromium	Chung et al. (1985); Jensen and Maurice (1980); Lien et al. (2004); Romoser et al. (1961)
Cobalt	Diaz et al. (1994)
Copper	Balevi and Coskun (2004); Dozier et al. (2003); Jensen and Maurice (1978); Lien et al. (2004); Mehring et al. (1960); Persia et al. (2004); Poupoulis and Jensen (1976); Smith (1969)
Lead	Burger and Gochfeld (1988); Edens and Garlich (1983); Edens et al. (1976); Finley et al. (1976); Hoffman et al. (1985); Kendall and Scanlon (1981, 1982); Morgan et al. (1975); Pattee (1984)
Mercury	Albers et al. (2007); Bennett et al. (2009); Heinz (1974, 1976a, b, 1979, 1980); Hill and Shaffner (1976); Hill and Soares (1987); Scheuhammer (1988); Spalding et al. (2000); Spann et al. (1986); Stoewsand et al. (1971)
Molybdenum	Lepore and Miller (1965)
Nickel	Cain and Pafford (1981); Eastin and O'Shea (1981); Weber and Reid (1968)
Vanadium	Davis et al. (2002); Ousterhout and Berg (1981); White and Dieter (1978)
Zinc	Dozier et al. (2003); Gasaway and Buss (1972); Oh et al. (1979); Persia et al. (2004); Roberson and Schaible (1960); Stahl et al. (1990)
Total PCBs	Ahmed et al. (1978); Bird et al. (1983); Britton and Huston (1973); Cecil et al. (1974); Custer and Heinz (1980); Dahlgren et al. (1972); Fernie et al. (2000); Fernie et al. (2001); Fernie et al. (2003a); Fernie et al. (2003b); Fernie et al. (2003c); Haseltine and Prouty (1980); Lowe and Stendell (1991); McLane and Hughes (1980); Peakall et al. (1972); Peakall and Peakall (1973); Platonow and Reinhart (1973); Risebrough and Anderson (1975); Scott et al. (1975); Tori and Peterle (1983)

PCB – polychlorinated biphenyl
TRV – toxicity reference value

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